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Dates of issue of Volume 73

No. 1, for January-February, 7 January 1946.
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No. 3, for May-June, 8 May 1946.
No. 4, for July-August, 3 July 1946.
No. 5, for September-October, 17 September 1946.
No. 6, for November-December, 15 November 1946.

ERRATA

p. 130, l. 8. For "*Siegsbeckia*" read "*Siegesbeckia.*"

p. 132. The varieties of *Psoralidium linearifolium* should read "*palodurense*" and "*texense.*"

p. 162–164. For "Loundes" read everywhere "Lowndes" [County, Georgia].

p. 302. Under *C. marginatum* var. *marginatum*, the word *tenue* following *C. maytenioides* β should be in italic.

p. 316, l. 16 from bottom. For "(1806)" read "(1896)."

p. 322, l. 20. Between "out" and "many" insert "not."

p. 323, l. 2. For "synonym" read "synonymy."

p. 358, l. 29. For *Solanum* "*amozonium*" read "*amazonium.*" l. 2 from bottom. For *Bursera* "*arborescea*" read "*arborea.*"

p. 359, l. 10. For "*Dyospiros*" read "*Diospyros.*"

p. 362, l. 14. The word species should be in Roman type.

p. 461, l. 1. For *Psittacanthus* "*macranthmus*" read "*macrantherus.*"

p. 468. For *Orythece* "*Schomburgkianum*" read "*Schomburgkiana.*"

p. 499, l. 3 above footnote. For *Tradescantia* "*caniculata*" read "*canaliculata.*"

FEB 1

BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 73, NO. 1, pp. 1–17 JANUARY, 1946

A NEMATODE–DESTROYING PHYCOMYCETE FORMING IMMOTILE SPORES IN AERIAL EVACUATION TUBES

CHARLES DRECHSLER[1]

A new nematode-destroying fungus which offers unusual features both in its parasitic development and in its asexual reproduction was obtained from partly decomposed leaves of the red maple (*Acer rubrum* L.) that were taken, on August 27, 1944, from a thick mat of decaying foliage bordering a pond several miles north of Georgetown, Delaware. At the time the collection was made, the mat, about 20 cm. in depth, held only such moisture as had been absorbed from the ground, but its low position must have exposed it to flooding whenever the pond was swollen by rain. In accordance with routine procedure small quantities of the friable detritus were added to maize-meal-agar plate cultures already thoroughly overgrown with either *Pythium ultimum* Trow or *P. undulatum* Petersen sensu Dissmann. During the ensuing two weeks various forms of animal life, including nematodes in large part referable to the genera *Acrobeloides*, *Aphelenchoides*, *Plectus*, and *Rhabditis*, multiplied freely in the cultures. The abundant eelworms soon were attacked by several widely distributed parasitic and predaceous hyphomycetes such as *Arthrobotrys oligospora* Fres. and *Harposporium anguillulae* Lohde. Somewhat later, 19 days after the plantings had been made, the new parasitic fungus was first observed in small quantity in one of the plate cultures. Afterward it came to light also in more than a dozen other cultures of the same series. In all the cultures it attacked only a single species of eelworm which Dr. G. Steiner has kindly identified as a species of *Acrobeloides* clearly distinct though not widely different from *A. bütschlii* (De Man) Thorne so prevalent in the vicinity of Washington, D. C.

The attack of the fungus begins with the adhesion of one or more of its conidia to the integument of a susceptible animal (fig. 1, a). Each of the adhering conidia puts forth a germ tube which maintains a width of approximately 1 μ in penetrating the host cuticle and in passing through the muscular body wall. When the body cavity is reached the germ tube immediately widens out in the manner of a pestle (fig. 1, b). The entire protoplasmic contents of the conidium then migrate into the expanded tip (fig. 3, a, b) to form a globose bud which soon detaches itself as a young thallus ready for para-

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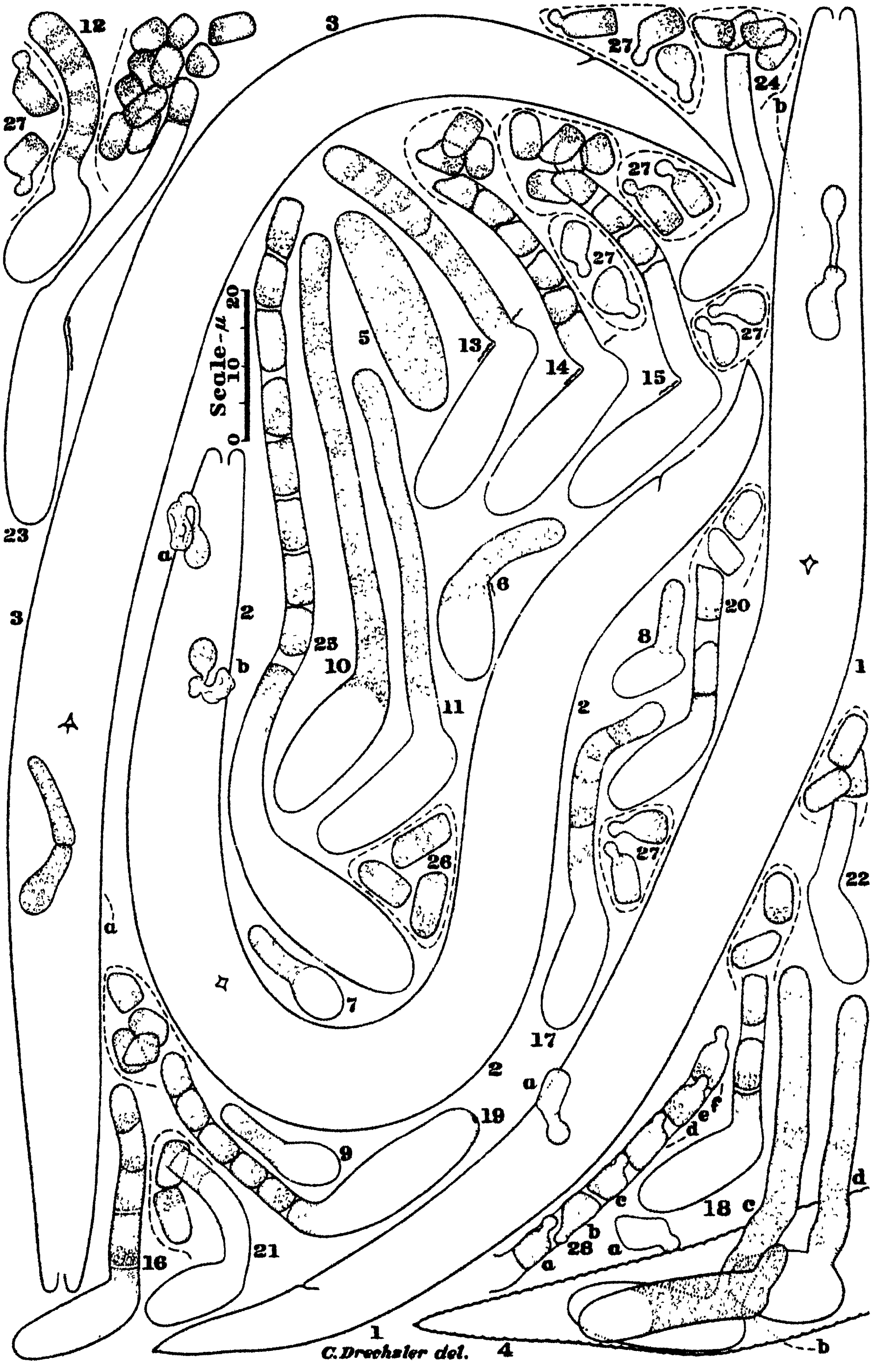

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sitic growth; the empty infection tube thereupon being nearly always lost to view, though the empty conidial envelope may often be seen affixed in much later stages (figs. 4, a; 33, a, b, c).

The young thallus, loose within the body cavity of the host, gradually elongates despite the frequently rather active bustling to which it is subjected by the animal's undiminished locomotion. When its length has come to exceed its width 3 or 4 or 5 times a cross wall appears in the middle, dividing it into 2 subequal cells (fig. 29) only slightly larger than the parent cell was originally. The 2 daughter cells grow somewhat in size as they become rounded off at the median septum in preparing for disjunction (figs. 2, a; 30), an event apparently hastened a little by the repeated flexural strains resulting from active movements of the eelworm. The separated unicellular bodies then gradually elongate and in due course, like their parent, undergo median partitioning and disjunction (fig. 31). Before long, on continued repetition of the same developmental sequence, a dozen thallodic cells are to be seen jostled about in loose disorder (fig. 32). Far from affecting these cells unfavorably, the jostling seems actually to help them in extending their distribution lengthwise within the animal, and more particularly in pushing them slowly through the narrowed portion of the body cavity where the

Explanation of figures 1–28

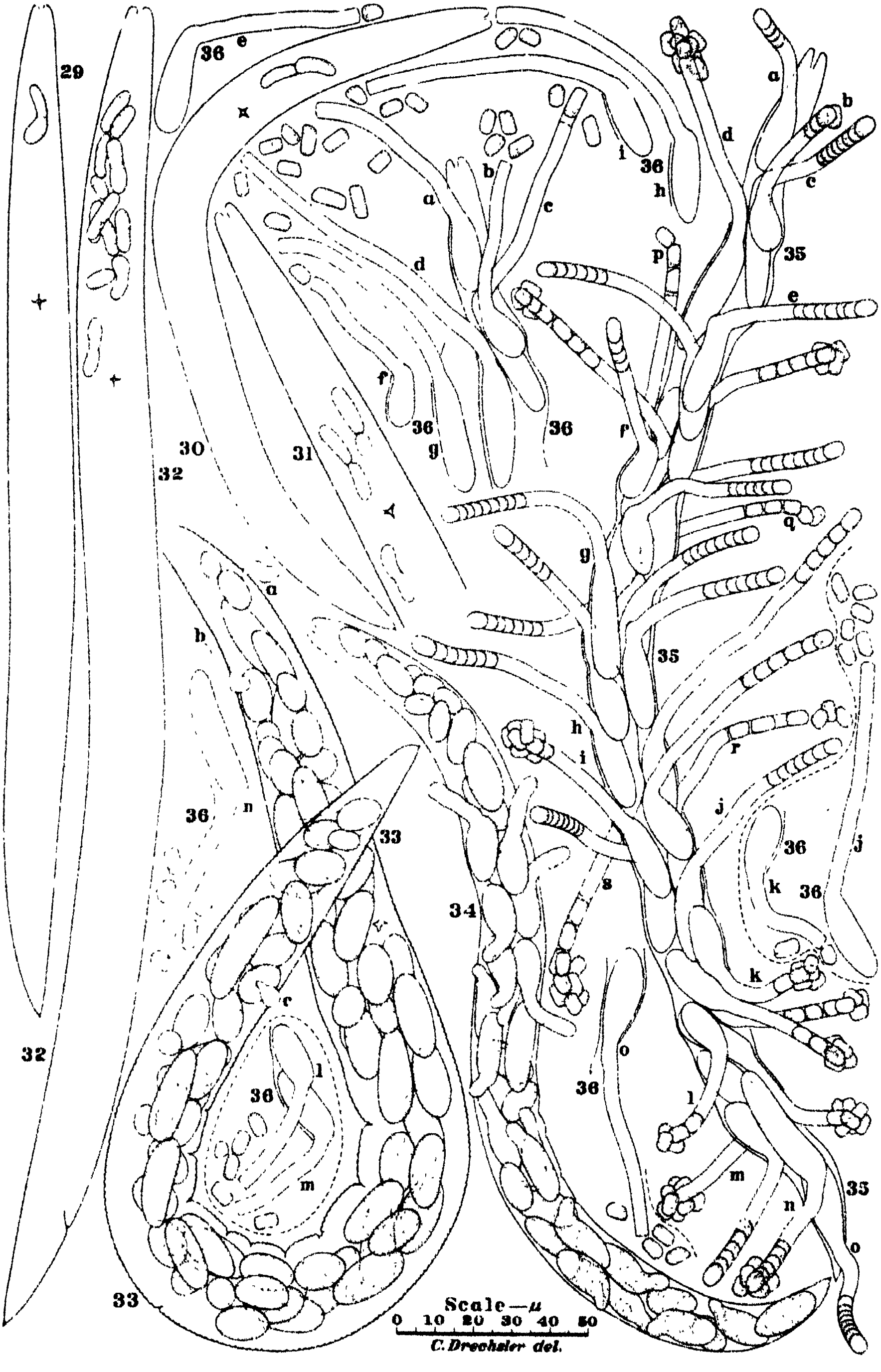
Gonimochaete horridula, drawn to a uniform magnification with the aid of a camera lucida; × 1000. Fig. 1. Small specimen of *Acrobeloides* sp. in early stage of infection from 2 adhering conidia, a and b; the infection tube from b is extended at an angle affording a good view. Fig. 2. Small specimen of *Acrobeloides* sp. with 2 adhering conidia, a and b, that have yielded their protoplasmic contents to the terminal enlargements within the body cavity of the host. Fig. 3. Small specimen of *Acrobeloides* sp. containing in its body cavity a uniseptate thallus whose 2 cells are about to become disjointed. Fig. 4. Posterior portion of infected specimen of *Acrobeloides* sp. with an empty spore envelope, a, adhering to it externally, and with 3 thallodic cells contained inside of it; one of the cells, b, having just begun to put forth a hyphal outgrowth, the other 2 cells, c and d, having each completed production of a hyphal outgrowth. Fig. 5. Large thallodic cell. Fig. 6. Thallodic cell in course of extending a hyphal outgrowth. Figs. 7–9. Thallodic cells with fully extended hyphal outgrowths. Figs. 10–13. Thallodic cells with hyphal outgrowths whose contents are arranged in alternate granular and homogeneous layers, indicating cleavage into spores. Fig. 14. Same sporangium as in figure 13, but after 3 spores have been liberated in a first discharge. Fig. 15. Same sporangium, again, as in figure 13, but after 2 more spores have been liberated by a second discharge. Figs. 16, 17. Thallodic cells with sporangial hyphae ready for discharge of spores. Figs. 18–22. Thallodic cells with sporangial hyphae, after discharge of a few spores from each. Fig. 23. Large thallodic cell whose sporangial hypha has liberated 10 spores, 1 spore being still attached to the closed end of the persistent basal part of tubular membrane; the proximal end of each spore is distinguished internally by an accumulation of granules. Fig. 24. Rather small thallodic cell whose sporangial hypha retains some protoplasm, after it has discharged 4 spores. Fig. 25. Large thallodic cell whose sporangial hypha retains some protoplasm and 8 spores, following the liberation of one or more spores at the tip. Fig. 26. Liberated spores of more than average size. Fig. 27. Spores that after their liberation have each put forth an adhesive protuberance. Fig. 28. Spores *a–f*, each of which has put forth an adhesive protuberance while still inside the envelope of the sporangial hypha.

oesophageal bulb occupies nearly the entire lumen of the body wall. Owing to the greater frequency of anterior infections, the portion of body cavity forward of the bulb is usually occupied earlier than the posterior portion. However, development of the fungus around the yielding intestine would seem to proceed more rapidly than about the resistant oesophagus, for when the thallodic cells have attained their definitive number they are usually found distributed rather evenly from one end of the animal to the other. As might be expected from the manner of multiplication, the definitive number of thallodic cells—commonly between 15 and 80—is little influenced by the number of original infections, but is determined primarily by the size of the individual animal host.

After their multiplication has ceased the thallodic cells grow in size without undergoing any pronounced change in their elongate ellipsoidal or occasionally subspherical shape. They increasingly choke the body cavity, yet for a protracted period the animal continues to move about with little show of distress or physical weakness. In many instances its behavior remains seemingly normal even after the total volume of the fungus cells appears approximately equal to the combined volume of its musculature and organs. Somewhat later, however, its locomotion slows down gradually and stops, disablement here being accompanied by incipient evanescence of the peripheral musculature. Usually the body wall backward from the oesophageal bulb begins to fade from view somewhat earlier than the anterior portion of the wall. In all cases, certainly, the oesophagus and bulb resist dissolution far better than the intestine or, indeed, than any other fleshy part. Thus, in the specimen shown in figure 33 the oesophagus and bulb, though crowded from their normal position, could still be clearly distinguished at a stage when all other contents had been reduced to diaphanous vestiges. Eventually these durable muscular parts also suffer obliteration in some degree, even if in more than a few instances they remain discernible when the thallodic cells

Explanation of figures 29–36

Gonimochaete horridula, drawn to a uniform magnification with the aid of a camera lucida; × 500. FIGS. 29, 30. Specimens of *Acrobeloides* sp., each infected by a single uniseptate thallus. FIG. 31. Anterior portion of a specimen of *Acrobeloides* sp. infected with 3 uniseptate thallodic bodies. FIG. 32. Specimen of *Acrobeloides* sp. infected with 12 thallodic bodies, some continuous, others uniseptate. FIG. 33. Large specimen of *Acrobeloides* sp. killed by parasite, following infection from 3 conidia, *a–c*, and development of 76 thallodic cells in its body cavity. FIG. 34. Specimen of *Acrobeloides* sp. killed and expropriated of contents through development of 40 thallodic bodies of the parasite; many of the bodies have begun to extend sporangial hyphae. FIG. 35. Integument of a specimen of *Acrobeloides* sp. occupied by 34 empty thallodic cells whose contents have been utilized for production of spores; most of the sporangial hyphae, including the 15 designated by the letters from a to o are shown in ascending posture; 4 others, p, q, r, and s, being shown in submerged positions. FIG. 36. Fifteen aerial sporangial hyphae, a–o, flattened down in a moist preparation under a cover glass; these being the same hyphae as those designated by corresponding letters in the preceding figure.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have manifestly concluded their vegetative growth, to proceed with asexual reproduction.

Reproductive development is initiated by the extension of a single stout hyphal outgrowth from one end (figs. 4, b; 34) or from a position close to one end (fig. 4, c, d) of the individual thallodic cell. To provide material for this outgrowth, the thallodic cell, which during the vegetative stage remains filled throughout with dispersedly granular protoplasm (figs. 5, 33), is progressively cleared of visible contents at the opposite end as if by the enlargement of a vacuole (figs. 4, b; 6; 34). The movement of materials proceeds steadily as the outgrowth forces its way through the host integument to continue its elongation externally (fig. 4, c, d). In occasional instances the protoplasmic column in the hyphal outgrowth may temporarily keep a slight foothold inside the ellipsoidal envelope (figs. 7–10) but as a rule this envelope is evacuated forthwith of all living contents.

A conspicuous characteristic of the hyphal element is its strong preference for aerial development. Since in agar cultures the host animals habitually live and feed on rather than under the surface of the substratum, they ordinarily succumb on the surface. For the most part, consequently, the hyphal elements after emerging from the host integument are free to follow their natural bent in choosing between submerged, procumbent, and aerial development. Although some of the hyphae, especially those arising from thallodic cells covered or laterally hemmed in by their fellows, thrust their way into the agar or grow procumbently over it, virtually all hyphae from favorably situated thallodic cells grow ascendingly into the air, and thus collectively offer a bristling appearance (fig. 35) when viewed under a microscope with a dry objective.

Soon after a hyphal element has attained definitive length its contents show significant changes. The granular constituents of its protoplasm, which during the period of growth remained rather evenly distributed (figs. 6, 7) are now brought together at intervals in a series of transverse clumps numbering usually fom 2 to 11 (figs. 4, c, d; 10–12). Beginning near the tip, lines of demarcation, often curving downward somewhat obliquely (figs. 13, 16, 17), appear below the individual granular clumps, at first being only faintly visible, but gradually becoming more and more distinct. Suddenly, with an abrupt though hardly violent upward movement of the whole stratified column, the 2 or 3 or 4 parts delimited by the uppermost lines are pushed forward; and as at the same time both their linear arrangement and their connections with one another become disrupted through buckling, they are revealed as discrete spores (figs. 14, 18, 19–22, 24). Apparently the newly liberated spores are somewhat adhesive, for in instances of aerial development they flip backward and remain clinging to the shortened hypha in an irregular cluster. The portions of protoplasm still in the hypha then undergo further gradual individualization, and after a period of perhaps 15 to 30 minutes 2 or 3 more spores are abruptly though gently pushed forward (fig. 15). Many of the shorter hyphal outgrowths discharge only once or twice, but the longer hyphae originating from the more voluminous thallodic cells (fig. 23) may give 3 or 4 puffs; each successive increment of spores, in the case of aerial hyphae, becoming agglutinated to those already clustered at the tip. Sometimes the lowermost spore remains in place, attached to the empty hyphal membrane (figs. 23; 36, c). The occasional instances where several spores or, at times, nearly all of the spores remain in alignment (fig. 25) until the enveloping hyphal membrane disintegrates must be held to have their explanation in partial or complete failure of the discharge mechanism.

Thus, in a general way, the hyphal outgrowth functions both as a sporangium and as an evacuation tube. Its operation in the latter capacity, however, shows marked peculiarity not merely in the gentle, intermittent propulsion of the spores, but also, and more especially, in a progressive wastage of the distal portion of the hyphal membrane, through which the original length of the membrane may be reduced by more than a half. It is not easily determined just how this wastage is accomplished. As the outgrowth before discharge reveals no conspicuous modification of its apex, there is reason to believe that the initial rupture of the membrane is not usually at the tip, but more often between the apical and the penultimate spore; wherefore it seems probable that in the very beginning the tubular envelope is shortened through removal of a distal portion adnate to the apical spore. If the first pufflike discharge leaves unoccupied a portion of hyphal envelope at the new apex, this ordinarily disintegrates quickly, thereby further shortening the tube. Similar loss of membrane takes place with each succeeding puff, until discharge is completed. Another peculiarity then becomes manifest in that the abbreviated hyphal membrane is usually not left open at the tip, like evacuation tubes generally, but is closed securely by a terminal wall (fig. 36, a–o). Where deposition of such a wall is omitted, as is frequently the case in specimens submerged in an agar mount prepared for study under the microscope, the hyphal membrane and the empty envelope of the thallodic cell promptly collapse and are soon lost to view. Where, however, the tip of an ascending aerial element has been closed, the entire membranous container, like an ancient skin bottle, retains its turgor and shape for a prolonged period, with the result that the shortened hyphal element continues to project upward, bearing aloft its cluster of spores. In fine, through closure of its tip the hyphal element that previously had served as sporangium and evacuation tube is enabled to operate as a sporophore. Occasionally hyphal outgrowths in submerged or procumbent positions likewise become sealed distally, though here it is not evident that any purpose could be fulfilled by the continuing turgor of the evacuated receptacle.

When newly liberated the spores (figs. 14, 15, 18–20, 22–24, 26; 36, a–o) are of a generally cylindrical shape. In the shorter specimens the length scarcely exceeds the width, while in the longer specimens it may slightly exceed twice the width. Most of the spores are somewhat unsymmetrically rounded or obliquely truncate at the ends; those formed terminally being, as a rule, quite readily distinguishable from their fellows since they regularly retain the symmetrically rounded apical contour of the parent hyphal outgrowth. All of them lack locomotor organs of any kind, and consequently are completely immotile. When brought into contact with a moist substratum they undergo incipient germination, each giving rise, often obliquely from one end, to a small excrescence (fig. 27) with a profile suggestive of the protruded head of a turtle. Judging from instances where frustration of the discharge mechanism has left the spores within the envelope of the parent hypha (fig. 28), the excrescence more often arises from the distal end (fig. 28, a, c–f) than from the proximal end (fig. 28, b). As might be surmised from analogy with similar development in other fungi parasitic on free-living terricolous nematodes, the germ protuberance is strongly adhesive and serves an important function in attaching the spore securely to the integument of a prospective host.

The vegetative development of the fungus can be followed no less clearly than its asexual reproduction, owing to the fortunate circumstance that animals infected by it suffer expropriation of their contents without showing the globuliferous degeneration through which the invasion of nematodes by nearly all parasitic and predaceous forms is often obscured to a troublesome degree. While the determination of its morphology and development in most particulars thus offers little difficulty, the taxonomic relationships of the fungus are not as obvious as might be desired. The general resemblance of its thallodic cells to the thalli of various zoospore-producing phycomycetes that have been made known as nematode parasites—*Chytridium endogenum* Braun (41), *Chytridium zooticum* Braun (2), *Catenaria anguillulae* Sorok. (7, 41), *Achlyogeton entophytum* Schenk (40), and *Myzocytium vermicolum* (Zopf) Fischer (11, p. 75; 44) may be cited as examples—immediately suggests that the immotile spores could well have been derived through evolutionary processes from some type of motile zoospore. Loss of motility in zoospores might, indeed, readily be associated with adaptation to parasitism on free-living nematodes, since the very active locomotion of these animals in itself provides adequate opportunity for encounter between host and parasite, thereby making independent movement of the parasite unnecessary, while at the same time encouraging strong adhesiveness as a feature of primary importance. The immotile spores of the fungus I have described (10) as *Haptoglossa heterospora* can be credibly interpreted as being homologous with zoospores not only by reason of their original subspherical shape and their violent discharge from massive sporangia formed from endoparasitic thalli, but by reason further of the persuasive parallelism that is evident when their emission of individual glossoid infective bodies is compared with the emission of a second zoospore stage in diplanetic development of the type familiar in *Achlya* and *Aphanomyces*. However the immotile spores of the Delaware fungus are not typically subspherical at any time, and do not reveal anything suggestive of diplanetism or of any other developmental feature especially characteristic of zoospores. In respect to their ambiguous morphology they invite comparison with the acutely pointed tapering immotile spores of the nematode parasite *Protascus subuliformis* Dangeard (8), which in shape likewise differ very markedly from zoospores, and which in manner of germination betray no particular homologies of any kind. If Maire (29) was able, with some credibility, to interpret the tapering spores as aplanospores equivalent to zoospores, it was mainly because the morphology of the thallodic sporangium in which they were formed and the violent manner of their discharge, together with the morphology of the sexual apparatus ascribed by Maupas (30) to *P. subuliformis*, gave grounds for recognizing a possible relationship to the zoosporiferous genera *Achlyogeton* and *Myzocytium*. While such relationship might be held similarly indicated for the Delaware fungus by the multiplication and outward morphology of its thallodic cells, parallelism with zoosporiferous phycomycetes generally is not well sustained either in the behavior of its hyphal outgrowths or in the intermittent maturation and discharge of its immotile spores.

What would seem in some measure a departure from the usual course of development among zoosporiferous phycomycetes is shown by the Delaware fungus in the complete evacuation of undifferentiated materials from the thallodic cell into a hyphal outgrowth corresponding structurally to the evacuation tubes of various chytrids and oomycetes. Yet however alien such transfer of protoplasmic materials, followed by zoospore or aplanospore individualization within the filamentous element, may be to the genera *Achlyogeton*, *Myzocytium*, *Protascus*, and *Haptoglossa*, similar movement of contents occurs as a rather commonplace event in the germination of some oospores. Thus, for example, when the oospores of my *Aphanomyces camptostylus* germinate by the production of zoospores, individualization of the swarm spores often takes place wholly within the germ hypha (9, p. 340, fig. 11, J). But while the sporogenous germ hyphae produced by *Aphanomyces* oospores are habitually extended into any deposit of liquid water that may be available, the sporogenous hyphal outgrowths of the Delaware fungus reveal a strong preference for aerial development wherever their positional relationships are not too unfavorable. To this preference, which even by itself would need to be regarded as very exceptional in an evacuation tube, are added further anomalous features in the curious evanescence of the distal portion of the hyphal membrane during spore discharge, and in the terminal closure of the empty proximal portion persisting after discharge is completed.

Most of the features that give difficulty in reckoning the Delaware fungus among the zoospore-producing phycomycetes find striking analogies in the entomophthoraceous nematode parasite I described earlier (10) as *Meristacrum asterospermum*. In one species as in the other the thallodic cells are completely evacuated of contents as the protoplasmic materials migrate into sporogenous hyphae that show a strong tendency toward aerial development. In both fungi, again, spore formation proceeds from the tip toward the base, and spore liberation is accompanied by rapid collapse and evanescence of a terminal portion of the hyphal membrane. The wall which in the Delaware fungus closes the empty portion of the sporogenous outgrowth offers good correspondence with the septum that in *M. asterospermum* proximally delimits the lowermost sporogenous hyphal segment. *M. asterospermum*, it is true, forms its immotile spores not endogenously, like the Delaware fungus, but in a typically exogenous manner by burgeoning them forth laterally from the several individual segments formed through deposition of cross-walls in the helicoid distal portion of the sporogenous hypha. Although these exogenous spores, or conidia, show unmistakable general resemblance to the much larger conidia familiar in the insectivorous Entomophthoraceae, they would seem more accurately homologous with the small secondary conidia whose production plurally from large primary conidia, following simultaneous emission of multiple sterigmata, was first made known by Costantin (5) as a distinctive feature of *Delacroixia coronata* (Cost.) Sacc. & Sydow (39, p. 457) and more recently was also observed by Couch (6) as an incidental phase in the development of his *Conidiobolus Brefeldianus*. In accordance with such homology the large conidium of *D. coronata*, and, by extension, the large conidia of the Entomophthoraceae generally, would be morphologically equivalent to the distal helicoid sporogenous portion of the hyphal element thrust into the air by the individual thallodic segment of *M. asterospermum*. Similar parallelism, but relating to endogenous immotile spores rather than to conidia, becomes evident when the Delaware fungus is compared with *Basidiobolus ranarum* Eidam: the distal sporogenous portion of the hyphal outgrowth in the former having its morphological equivalent in the large conidium of the latter; and the immotile spores of the former corresponding to the secondary bodies formed plurally, according to Levisohn's (28) account, within the large conidia of the latter after their ingestion by frogs, or often, too, on immersion in a glycerin-peptone-glucose culture solution. Levisohn discussed the endogenous bodies merely as products of multiplication, referring to them and to their development in language (Tochterzellen, Abkömmlinge, Darmform, Konidienzerfall, Hyphenzerfall, Teilung) even less connotative of homologies pertaining to reproduction than the term "Palmellastadium" by which Raciborski (38) had earlier designated aggregations of similar bodies he found produced within mycelial segments when he grew *B. ranarum* in a culture solution containing ammonium sulphate and glucose. Nevertheless in subsequent text-books on mycology (13, p. 118, 119; 12, p. 285; 1, p. 115–117; 14, p. 147) the endogenous bodies have been interpreted as sporangiospores, and for the most part Levisohn's findings seem to be construed confidently as having established the sporangial nature of the large conidia common to nearly all known members of the Entomophthoraceae. It is not difficult to understand how an investigator dealing at first hand with *B. ranarum* might well be reluctant to use terminology distinguishing between asexual reproduction and vegetative segmentation, for in that fungus, under natural conditions, the development corresponding to the formation of endogenous spores in the hyphal outgrowths of the Delaware parasite takes place, apparently without much spatial separation, in the same milieu—the interior of the frog's alimentary tract—as the vegetative multiplication corresponding in the Delaware parasite to the repeated fission of young thallodic cells inside the body cavity of the nematode host. The circumstances making for confusion of the reproductive and vegetative stages in *B. ranarum* are wholly absent in the Delaware fungus; so that this fungus—unless the parallelisms it offers are misleading—displays advantageously what would appear to be the primal manner of asexual reproduction in the family. The difference between its method of spore formation and the method of spore formation in *M. asterospermum* seems approximately of the same sort as the difference between the types of asexual sporulation found, respectively, in *Mucor* and *Cunninghamella;* though the *Dictyuchus*-like partitioning of the sporogenous hyphal tip in *M. asterospermum* has no equivalent in *Cunninghamella* nor, for that matter, in *D. coronata* and *C. Brefeldianus*. It may be noted that the spores of *M. asterospermum* put forth no special adhesive protuberance, but become affixed to the animal host by means of adhesive material which they exude without undergoing any modification in outward shape. Again, instead of increasing numerically by repeated fission during the earlier stages of invasion, the infective cell of *M. asterospermum* grows into a stout massive hypha before division by deposition of cross walls takes place preliminary to disjunction.

If among the groups of phycomycetes mainly endoparasitic on animals and reproducing asexually by immotile aerial spores the Delaware fungus is brought into alignment with the Entomophthoraceae by virtue of its ready fissiparous multiplication, it is through this same feature of vegetative development estranged from the Zoopagaceae; since in the latter family thallodic or mycelial disjunction is wholly unknown, and apart from the septa associated with reproduction, transverse walls are laid down within thallus, hypha, or germinating conidium solely as retaining walls to mark successive stages in the evacuation of these structures. Then, too, the contents of the disjointed vegetative cells show sharp contrast between the sappy protoplasmic matrix and the granules scattered through it in moderate numbers, whereas the denser protoplasmic matrix in the thalli and vegetative hyphae of the Zoopagaceae often obscures the granular constituents rather markedly. Although in the Delaware fungus the spores usually do not appear spatially separated from the membrane of the hyphal outgrowth within which they are formed, their visible movement upward through the lumen of the membranous envelope gives ample evidence of their endogenous origin. Among the Zoopagaceae, on the other hand, movement of spores within the membrane of a parent hyphal element has never been observed. Except for the empty membranous appendages borne on the conidia of some species, the spores throughout that family are indistinguishably fused with the membrane originally surrounding them; and after disarticulation each spore retains the adnate portion of original membrane as an integral part of its wall. Even the restricted analogy in sporulation offered by the three catenulate genera of the Zoopagaceae is absent in the five zoopagaceous forms that have so far been described as parasitic or predaceous on nematodes, since none of these five forms produce their spores in chains. However among the fungi found destructive to nematodes in agar-plate cultures planted with decaying vegetable materials catenulate sporulation very similar to that known in the Zoopagaceae occurs in representatives of the group of minute aerially sporiferous organisms that have been customarily referred to *Actinomyces*, though a genus of less ambiguous application is now available—if the lack of a Latin diagnosis can be overlooked—in *Streptomyces* Waksm. & Henr. (43). These organisms, which from their morphology seem best referable to the Phycomycetes, include not only many species parasitic on nematodes (*Bunonema* is attacked especially often) but also species destructive to various amoebae ,and to testaceous rhizopods of such genera as *Euglypha*, *Geococcus*, *Heleopera*, *Sphenoderia*, and *Trinema*.

Truly endogenous development of reproductive bodies in linear arrangement within basally attached unbranched filaments occurs certainly in a group of curious animal-inhabiting organisms, somewhat unfamiliar to mycologists though presumably referable to the Phycomycetes, of which the first representatives were made known by Leidy (24, 25, 26, 27) nearly a century ago in his original descriptions of *Enterobryus elegans*, *Enterobryus spiralis*, *Enterobryus attenuatus*, *Eccrina longa*, and *Eccrina moniliformis*,—all based on specimens found in the alimentary canals of different arthropods. *Enterobryus elegans* offers particular interest here as it was not only found attached to the mucous membrane of the small and the large intestine of its millipod host, *Julus marginatus* Say, but was also observed growing from the exterior of the three nematode species—*Ascaris infecta* Leidy, *Streptosomum agile* Leidy, and *Thelastosomum attenuatum* Leidy—infesting the cavities of the viscera mentioned. Despite the development of *E. elegans* on nematodes, Leidy's account of this organism can hardly be considered directly suggestive of the Delaware fungus since in the relevant figures (27, pl. 1, fig. 1, e, f, i; pl. 4, fig. 28, b, c) its very few large propagative bodies, or "secondary cells" would seem to be formed through *Oidium*-like segmentation; and similar segmentation would likewise seem illustrated in the figures relating to "secondary-cell" production in *E. spiralis* (27, pl. 1, fig. 4, d) and *E. longa* (27, pl. 5, fig. 1–6). Closer resemblance to the Delaware fungus is, however, evident in the illustrations pertaining to asexual reproduction in some of the organisms more recently described, again from the digestive tubes of arthropods, as members of the group Eccrinides erected in 1905 by Léger and Duboscq (17) to include besides Leidy's two genera the type genus *Arundinella* (now *Arundinula*) then newly erected by them. This group, subsequently augmented through assimilation of *Amoebidium* Cienk. (4) and through addition (18, 19, 20, 21, 22, 23) of eight new genera, including three contributed by Poisson (32, 33, 34, 35, 36, 37), was in 1929 ranked by its authors (22) apparently as a subclass (Eccrinideae) in the Phycomycetes under which were subsumed two separate orders, the Eccrinales with three families and the Amoebidiales with one family. From the descriptions and figures given by Léger and Duboscq and by Poisson, the spores of the Eccrinales are formed endogenously. The "macroconidia" of these authors, though apparently corresponding to Leidy's "secondary cells," seem much less suggestive of oidia. Where the French investigators show relatively short thalli in process of forming the small reproductive bodies designated by them as "microspores," as, for example, in a specimen of *Parataeniella intermedia* delineated by Poisson (35, p. 205, fig. XX, E), it is easy to recognize general similarity to hyphal outgrowths of the Delaware fungus, such as those illustrated herein in figures 4, 10, 11, 12, and 13. Since my fungus has so far not been seen to produce any spores of strongly indurated character, grounds are lacking for any comparison with the seriately arranged, transversely oriented, thick-walled reproductive bodies of the Eccrinales, which the French writers term "spores durables," and which Poisson (36, p. 60, 65) took occasion to distinguish from the "cysts" of Thaxter's *Enterobryus compressus* (42) as well as from the "oospores" of Hauptfleisch's *Astreptonema longispora* (15), a related species first placed in the Saprolegniaceae but later (16) surrendered to the protozoologists. My fungus has shown nothing in its sporangial outgrowths analogous to the expanded terminal "gland" present in some members of the Eccrinales, which by breaking down permits apical liberation most usually of microspores; and the disintegration of its sporangial membrane seems too rapid and disorderly to afford any very close parallelism with the manner of dehiscence by lateral apertures that occurs among the Eccrinales more especially in the liberation of macrospores and resting spores. Further, the well-developed endoparasitic thallodic cells of my fungus have no recognizable equivalent in the Eccrinides, as the tubular thalli of those organisms are only slightly inserted into the host tissues, more or less after the manner familiar in the genus *Harpochytrium* Lagerheim; while *Asellaria Caulleryi*, a somewhat related branching parasite described by Poisson (37) from the intestines of isopods has no attachment at all. Production of amoebospores in addition to immobile spores, such as occurs in *Amoebidium parasiticum* Cienk. (4), where according to Cienkowski's account the amoebospores after their encystment may form several curved immotile spores endogenously, is wholly alien to my fungus. This distinctive type of reproduction, which led Bütschli (3, p. 611–614) and Minchin (31, p. 313–314) to subsume *A. parasiticum* under the Protozoa, is present in the genus *Paramoebidium* Lég. & Dub. (23) to the exclusion of endospore formation; and though absent throughout the order Eccrinales is held to be of primary significance in considerations touching the fundamental character and taxonomic relationships of the entire group.

The Delaware parasite, as has been intimated, appears best interpretable as a primitive member of the Entomophthoraceae. To provide a suitable place for it, a new genus is proposed under a name compounded of two words meaning "fertile" and "hair," respectively.

Gonimochaete Drechsler, gen. nov. Parasitus intra animalia viventia crescens; cellulis nutritis juvenilibus ejus septo in duos loculos identidem se dividentibus, his loculis inter se disjungentibus, itaque stato assumenti postremo ex corporibus unicellularibus disjunctis incoloratis constante; post mortem animalis corporibus vulgo globosis vel ellipsoideis, quoque omne protoplasma tradente dum hypham fertilem extra integumentum saepe in aerem rarius in materiam subjacentem vel ambientem proferente; quaque fertili hypha sporas immotas incoloratas in unicam seriem penitus gignente denique eas expellente simul membrana ipsius in parte superiore evanescente, tamen parte inferiore ascendente sursum muro clausi saepe paulo longius persistente.

Parasite growing within minute animals, its assimilative cells early in development repeatedly becoming divided by a cross-wall, and the two segments in each instance separating from one another, so that eventually the vegetative state consists of disjointed colorless unicellular bodies; the bodies commonly globose or prolate ellipsoidal in shape, each of them yielding all its protoplasm in putting forth a filamentous hypha which after emerging from the host integument most often projects into the air, though at times creeping over or extending into the surrounding material; each hypha producing internally a row of colorless immotile spores, then expelling them while simultaneously the upper portion of hyphal membrane collapses and vanishes, though the lower portion often becomes closed by a distal wall and then persists some time longer in an ascending posture.

Gonimochaete horridula Drechsler, sp. nov. Corpora assumentia incolorata, multa (saepius 15–80) in vermiculo nematoideo oriunda, in maturitate globosa vel elongato-ellipsoidea, plerumque 6–33 μ longa, 5.5–10.5 μ crassa, primo protoplasmatis disperse granulosi repleta, deinde ex uno extremo hypham fertilem promittentia itaque omnino se exinanientia; hyphis fertilibus incoloratis, vulgo plerumque ascendentibus (itaque conjunctim horridulis), 10–100 μ longis, 2.8–5 μ crassis, 2–12 sporas immotas intus gignentibus, binas vel ternas vel quaternas leniter eas deinde expellentibus, postremo eas apice clausa partis interioris vacuae 5–80 μ longae sustinentibus; sporis incoloratis, cylindraceis, utrimque inaequaliter rotundatis vel oblique rotundo-truncatis, 4–9.5 μ longis, 3–4.2 μ crassis, dejectis gemmam glutinosam 1.5–2.5 μ longam 1.5–2 μ crassam saepe oblique ex uno extremo emittentibus.

Habitat in *Acrobeloideo* sp. in foliis *Aceris rubri* putrescentibus prope Georgetown, Delaware.

Assimilative bodies colorless, often developing in numbers from 15 to 80 in an individual nematode host, when full grown mostly 6 to 33 μ long and 5.5 to 10.5 μ wide, at first filled with dispersedly granular protoplasm, each later becoming completely evacuated in giving rise from one end to a single hypha; the hyphae colorless, often mostly ascending (and thus collectively offering a bristling appearance), 10 to 100 μ long, 2.8 to 5 μ wide, individually producing 2 to 12 immotile spores internally, then expelling them weakly mostly 2 or 3 or 4 at a time, and afterwards often holding them aloft at the closed tip of an empty lower part 5 to 80 μ in length; spores colorless, cylindrical, mostly rather irregularly rounded or somewhat obliquely truncate at both ends, 4 to 9.5 μ long, 3 to 4.2 μ wide, each eventually when lying on the substratum budding forth a bulbous adhesive protuberance, 1.5 to 2.5 μ long and 1.5 to 2 μ wide, usually somewhat obliquely from one of its ends.

Destroying nematodes belonging to a species of *Acrobeloides* it occurs in decaying leaves of *Acer rubrum* near Georgetown, Delaware.

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CYTOGEOGRAPHY OF EMILIA CASS. IN THE AMERICAS

J. T. BALDWIN, JR.[1]

Emilia Cass. is a genus of Compositae with, perhaps, a score or more species native to the tropics of the Old World. Two species are widespread in the American tropics as introduced weeds: *E. sonchifolia* (L.) DC. and *E. coccinea* (Sims) Sweet. Cytogeographic occurrence of these two species in the Americas is considered here.

E. sonchifolia (fig. 1) is an annual that, under favorable conditions, may come from seed to maturity within thirty days. In the Amazon Valley this species was observed to flower and fruit during every month in the year. Always the flowers were purplish pink, though the literature indicates those of some plants to be reddish. The chromosome number is $2n = 10$, $n = 5$ (figs. 2–4). The chromosomes were studied in aceto-carmine smears of leaves and of pollen mother cells. The following collections—of which specimens have been deposited in the Instituto Agronômico do Norte, U. S. National Museum, and New York Botanical Garden—were examined cytologically:

Source	*Habitat*	*n*	*2n*	*Collector's Number*
Pará, Brazil				
Oriximiná	mandioca field		10	*Baldwin 2973*
Obidos	grassy area in town		10	" *2970*
Juruty Novo	sandy field		10	" *2995*
Fordlandia	golf course		10	" *2713*
Belterra	*Hevea* planting		10	" *2705*
Alemquer	field		10	" *2969*
Bragança	railroad bank		10	" *4024*
Belem	*Lonchocarpus* planting	5	10	" *2704*
Amazonas, Brazil				
Manáos	public square		10	" *2784*
Guajará-Mirim	railroad bank		10	" *3118*
Porto Velho	railroad bank		10	"
Rio de Janeiro, Brazil	weed in garden		10	" *4577*
Zandary Field, Surinam	edge of airfield		10	" *4579*
Waller Field, Trinidad	edge of airfield		10	" *4580*

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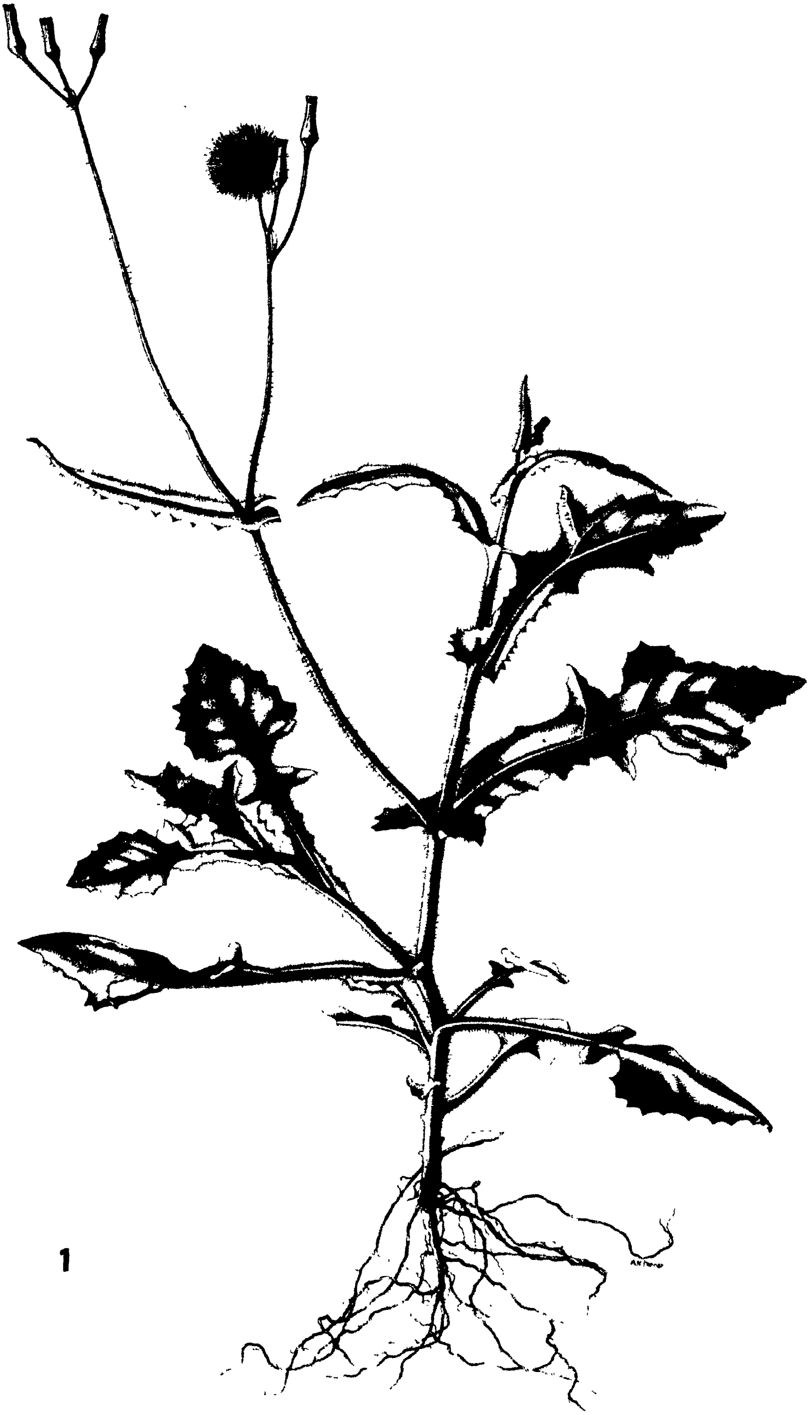
[1] Observations on which this report are based were made while the writer was an agent for the U. S. Department of Agriculture and were incidental to assignment in South America. Appreciation is here expressed to Felisberto Camargo, Director of the Instituto Agronômico do Norte, Belem, Pará, for cordial coöperation, to Anna Ferraz for making the drawing of *E. sonchifolia*, to S. F. Blake for determining the identity of a specimen of *E. coccinea*, to the curators of the herbaria of the U. S. National Museum, Chicago Natural History Museum, New York Botanical Garden, and the University of Michigan for loans of specimens, and to the American Geographical Society for permission to reproduce the map.

The illustrations are published with the aid of the Marcus Lucien Underwood Memorial Fund.

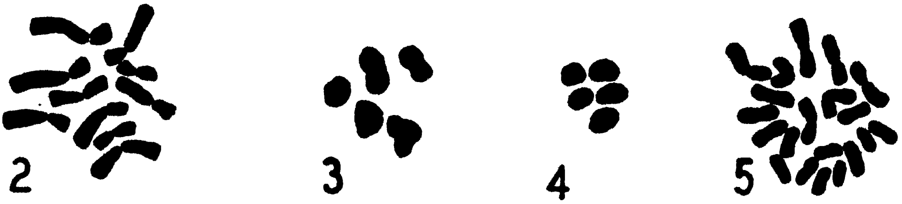


1

FIG. 1. *Emilia sonchifolia* (L.) DC. in flower and fruit from Belem, Pará, Brazil. × 0.5. Drawn by Anna Ferraz.

The species usually occurs in dry, sandy situations, where it may form thick stands. It is not, however, a serious weed; it cannot compete with rank-growing vegetation.

E. coccinea is likewise annual. Its maturation is less rapid than that of *E. sonchifolia* and, in comparison with the latter species, is tetraploid: $2n = 20$ (fig. 5). It is sometimes planted for its attractive red flowers (Standley 1928), as in the Jardim Botanico do Rio de Janeiro (*Baldwin 4578*: $2n = 20$). Weeds from the following places were examined cytologically:



FIGS. 2–5. Chromosomes of *Emilia*. FIGS. 2–4, *E. sonchifolia*, mitotic and meiotic (I & II) metaphases: $2n = 10$, $n = 5$. FIG. 5, *E. coccinea*, mitotic metaphase: $2n = 20$. × 2750.

Source	*Habitat*	$2n$	*Collector's Number*	
Pará, Brazil				
Fordlandia	golf course	20	*Baldwin*	*2712*
Belem	*Hevea* planting	20	"	
Amazonas, Brazil				
Manáos	vacant lot	20	"	*2792*
Labrea	beside path	20	"	*2935*
Guajará Mirim	railroad bank	20	"	*3118A*
United States				
Fort Meyers, Lee Co., Florida		20	*P. C. Standley*	*73322*

Specimens are in the herbaria mentioned above.

E. coccinea, as a rule, prefers a more fertile and moister situation than *E. sonchifolia* does, and it has a more robust stature; it may be somewhat troublesome as a weed. The two species were found growing together at Fordlandia, Guajará-Mirim, Manáos, and Belem. Intermediacy between the species was not observed. Nor in herbarium material were intergradations noticed. The diploid-tetraploid relation may act as an hybridization barrier.

Observations on these two species are in agreement with the statement of Cockayne et al. (1932) relative to the flora of New Zealand: "the exotics for the most part are annuals, occasionally biennials, in form unlike nearly all the indigenous species, usually producing a much greater number of seeds, with more rapid germinating power and probably greater viability. As for their habitats, the exotics affect cultivated ground and such as has been laid bare in the process of settlement—they are, as it were, the companions of man."

Ochse (1931) and Merrill (1943) indicate that whole plants of *Emilia* serve in the East as either cooked or raw food: such use in the Americas is not known to the writer. Except for the degree to which *E. coccinea* has been planted as an ornamental, spread of the genus in this hemisphere seems to have been dependent wholly upon chance. Entry of both species was apparently from the Atlantic side (figs. 6, 7). In spite of the fact that suitable habitats in the Amazon Valley are at distant points in vast stretches of forest, occurrence there is rather marked. Movement into the interior has been along routes of travel and is in large measure reflection of the extent in time and space that man has disturbed the vegetation. Consequently, it is not surprising to find *E. sonchifolia* along both the railroads in the Amazon Valley—the Bragança and the Madeira-Mamoré, on both the Belterra and the Fordlandia rubber plantations, and along the Amazon. But it is worthy of record that at this date the species seems not to occur along the Rio Negro between

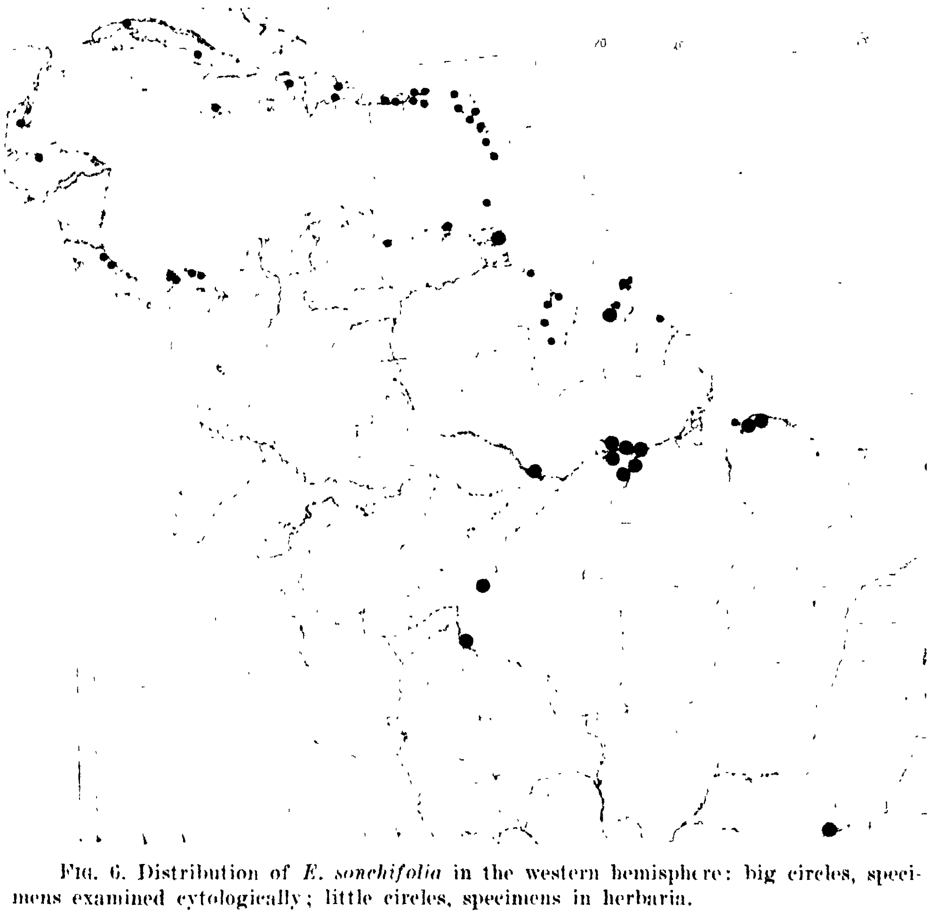


FIG. 6. Distribution of *E. sonchifolia* in the western hemisphere: big circles, specimens examined cytologically; little circles, specimens in herbaria.

Manáos and the Venezuelan border, nor along the Solimoes, Purús, Juruá, and Marañon, nor in the rather thickly settled Acre Territory of Brazil and the adjacent low country of Bolivia, nor in Matto Grosso about the old towns of Corumbá, Cuyabá, and Rosario Oéste. In due time the plant will doubtless become established in those places: the situations seem favorable, and the species has effective means of transport; it was, for instance, one of eight Compositae that by natural means covered the twenty-five miles from Java to Krakatau, where it entered into the flora (Ridley 1930).

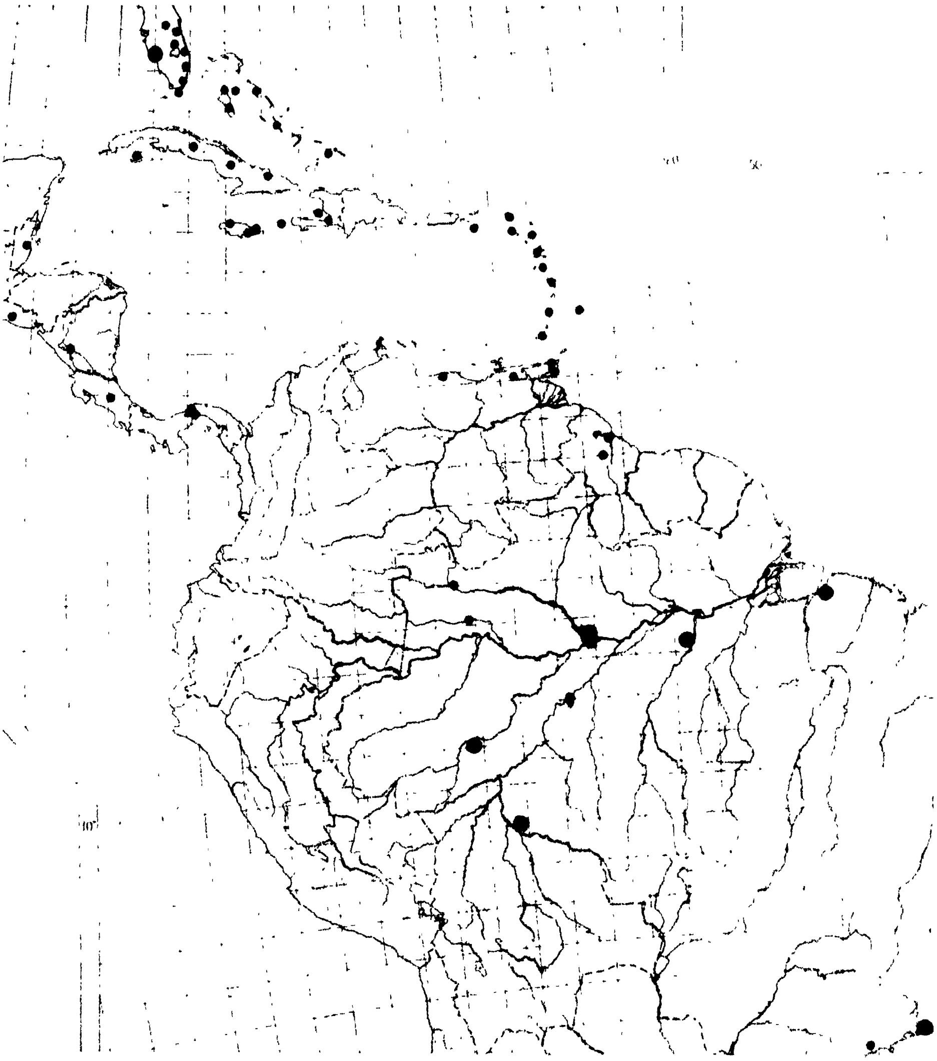


FIG. 7. Distribution of *E. coccinea* in the western hemisphere: big circles, specimens examined cytologically; little circles, specimens in herbaria.

As revealed in this study, *E. sonchifolia* (fig. 6) has a range from ca. 23 degrees north to ca. 23 degrees south; *E. coccinea* (fig. 7). from ca. 29 degrees north to ca. 24 degrees south. Inclusion by Small (1933) of Florida within the range of *E. sonchifolia* is questioned. The species has undoubtedly been introduced there, but it seems not to have survived as an integral part of the flora, whereas *E. coccinea* is a not uncommon weed in southern Florida. It is considered that the northern occurrence of the two species is rather correctly shown on the maps, but the distribution mapped here for the continent of South America is merely suggestive of the actual ranges, for sufficient herbarium specimens were not available for study. It is clear, however, that *E. coccinea* has the greater latitudinal range, which may be correlated with the tetraploid nature of this species as contrasted with diploid *E. sonchifolia*. Nevertheless, the distributional areas of the two weeds are too similar, and that of the diploid too great, to adduce *Emilia* to the support of Huxley's (1943) statement: "Many widespread weeds of cultivated and waste lands are also tetraploid forms, the diploid types having quite restricted distribution." But, of course, one recognizes that for purposes of comparison and contrast only intraspecific polyploidy usually has much significance.

SUMMARY

E. sonchifolia (L.) DC. and *E. coccinea* (Sims) Sweet are widespread in the American tropics as introduced weeds. Fourteen collections of one, seven of the other, were examined cytologically. *E. sonchifolia* is diploid ($n = 5$, $2n = 10$), and *E. coccinea* is tetraploid ($2n = 20$). Though the species sometimes grow together, no indication of hybridity was found either in nature or in herbarium material. The diploid plant matures quicker, is of smaller size, prefers a drier habitat, and has a less extensive north-south range than the tetraploid.

THE BLANDY EXPERIMENTAL FARM
BOYCE, VIRGINIA

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JEROME BOG, A PEAT-FILLED "CAROLINA BAY"

MURRAY F. BUELL

This study presents a description and the dynamic relationships of the bog vegetation characteristic of peat-filled "Carolina bays." The somewhat similar "pocosin" or "bayland" vegetation of the low, flat peatlands of eastern North Carolina has been described by Wells (1928, 1932), and by Dachnowski-Stokes and Wells (1929). More recently Wells (1942) has summarized our knowledge of the bog vegetation on the southern coastal plain. Yet no previous detailed study has been made of the vegetation of the peat-filled lake basins of this area. This paper is the result of such an investigation. It is concerned with a strictly delimited bog area giving a correlation of the distribution of the communities with certain physiographic features characteristic of the basin and its peat deposit. Besides the vegetation study, further information is added to our knowledge of the "Carolina bays" in the profiles showing the shape of the basin and the peat deposit which has accumulated in it.

This description of the basin may help a little in explaining the origin of a very perplexing physiographic feature. The elliptical depression occupied by this bog is one of a large number of similar basins in the region. Melton and Schriever (1933) gave the first detailed description of these remarkable depressions on the coastal plain and suggested a meteorite origin. Cooke (1934) and Johnson (1937) have both been critical of this hypothesis and have made other suggestions regarding the origin of the bays. Cooke believes they were formed by currents in coastal lagoons. Johnson proposed a theory of complex origin postulating a combination of artesian springs and underground solution causing subsidence together with lacustrine modification. All studies pertaining to the bays have been recently summarized by Johnson (1942).

Jerome bog is a perfect example of the "Carolina bays." It occurs in a sandy plain astride the Bladen–Cumberland County boundary line, just east of the hamlet of Jerome, North Carolina. It is almost perfectly elliptical with its long axis running northwest-southeast. There is a ridge of coarse white sand rising to about ten feet above the level of the bog at the southeast end, diminishing gradually northwestward around the margin of the bog and absent entirely at the northwestern end. Its height at the southwest end has been reduced by wind erosion at some earlier period, much of the sand having been blown toward the northeast. The vegetation of the sand ridge as well as the sand plain to the west and northwest is the longleaf pine–turkey oak type (*Pinus palustris—Quercus catesbaei*) described by Wells and Shunk in 1931. There is some cultivated land west of the bog. To the northeast is a swamp into which the bog drains. Bog vegetation occupies a small bay just to the east and a low area toward the south.

The process by which such lake basins were filled in by peat must have been similar to those described for the few remaining bog lakes in this vicinity (Buell 1939).

METHODS

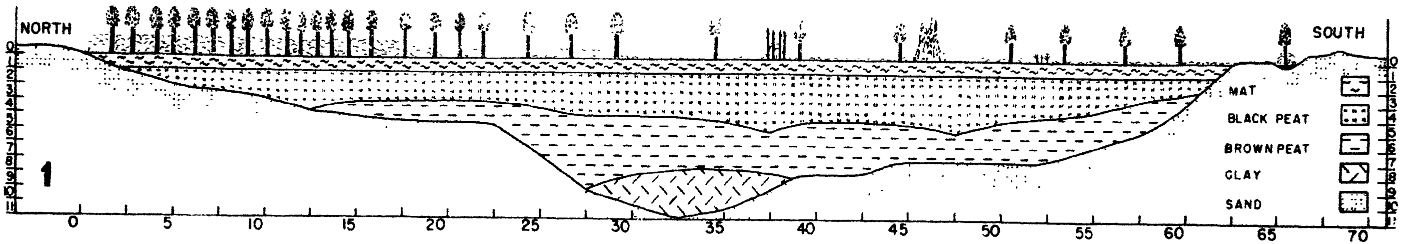
Peat profiles were obtained by sampling the deposit at 250-foot intervals along both the long diameter and the short diameter of the bog except across the northwest end where 500-foot intervals were used. Samples were taken with an American Peat Sampler (Davis type) at one-foot vertical intervals. The datum of reference for constructing the profiles was the bog surface, which was assumed to be level.

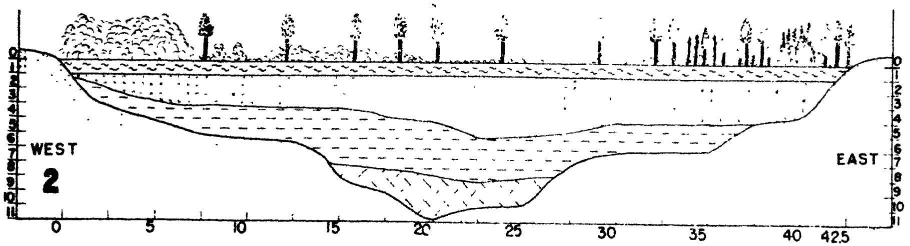
Levels were run to determine the corresponding height of the bog at the southeast end and at the drainage outlet. An arbitrary bench mark was selected half way along the east side of the bog and a traverse run to the southeast end and the outlet respectively. At the southeast end a line was run away from the bog up over the sand ridge while another was run out onto the bog itself. Although the unstable surface precluded accurate leveling, this line was continued 600 feet from the margin. Numerous readings were taken from three different places established along this line. These readings were of points on the bog surface taken at random. The bog level arrived at in each case is the average of the readings so obtained. Similar readings were taken on the bog surface 150 feet southeast of the outlet.

The survey of the vegetation was made along the same transects as the peat profiles. At each station where borings were taken the species present were listed and their abundance recorded using a scale of five. This listing and estimate of species abundance at each station together with general observations during the course of the field work are the basis of the description and discussion of the vegetation which follows.

THE BOG PROFILES

The basin in which the bog occurs has a broad, shallow shelf at the northwest end which drops more or less abruptly to the deepest point at the center lying in a trough-like depression extending to the southeast end. The profile of the long diameter reveals a broad shelf descending gradually from the northwest end for about 2250 feet at which point it is overlain by about four feet of peat (fig. 1). Here the shelf ends abruptly in a comparatively steep drop to the center which, a thousand feet farther on, is overlain by eleven feet of deposits. Southeastward the basin continues slightly shallower,





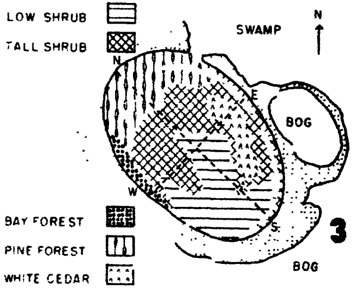


FIG. 1. Profile of Jerome bog along the long diameter. Diagram of vegetation shows the pine forest extending about 2,000 feet from the north end. The tall shrub community ends about 1,000 feet farther on. The low shrub community occupies the rest of the transect except where it cuts through a clump of dead white cedars at about 3,100 feet and the living white cedar forest at 4,600 feet. At 4,250 feet is a clump of *Cyrilla racemiflora*. At 6,250 feet is the sand bar, at 6,500 feet the bog lagoon. The profile of the sand rim is correct but the scale is about $\frac{1}{10}$th that used for the bog profile, its maximum height at 6,850 feet being about equal to the greatest depth of the basin. The vertical scale below the bog surface is given in feet, the horizontal scale is in hundreds of feet. FIG. 2. Profile along the short diameter. At the west end is the bay forest. Between the bay forest and a point about 2,000 feet from the west end is the tall shrub community. The low shrub community occupies the center but shows a gradual transition eastward to the tall shrub community. Burned and living groves of white cedar are shown toward the eastern margin. Scale is the same as in figure 1. FIG. 3. Map of Jerome bog showing distribution of plant communities and location of the transects. For scale compare figures 1, 2.

the bottom rising only gradually, until at about 5500 feet from the northwest end it rises abruptly from a depth of six feet to a low sand bar 750 feet beyond. Behind the sand bar is a bog "lagoon" and finally the rapid rise to the top of the sand rim which reaches a maximum height of ten feet above the bog at a point 450 feet beyond the margin. Hence the height of the sand rim above the bog surface is about equal to the greatest depth of the bog.

The profile along the short diameter, that from the east to the west sides of the bog, shows that the deeper part of the basin is a trough with a broad shelf on either side (fig. 2). On the east side of the trough the bottom rises in a series of two benches, a lower, broader one of six feet depth, an upper, narrower one of four feet depth. On the other hand, west of the trough the slope is continuous.

For the purpose of this present study the bog deposits are classified simply as clay, brown peat, and black peat overlying each other in that order. The clay is white and toward the bottom is mixed with varying amounts of the underlying coarse sand. Toward the top it contains bits of wood and other plant fragments. The brown peat differs considerably from place to place. It contains varying amounts of partially decomposed macroscopic fragments and here and there an abundance of logs that occasionally are so numerous as to make boring very difficult. Pollen has been well preserved and is abundant in this peat. On the other hand the black peat that overlies it is very fine, soft and sticky when wet, and dries to a hard, brittle mass. It consists of small bits of charred plant fragments and quantities of fine charcoal. Pollen is fairly abundant in the lower portion of the black peat but in the upper foot it is neither abundant nor well preserved. The surface of the bog is a continuous thick, coarse, tough mat of tree roots and the roots and rhizomes of shrubs.

The stratification of these types is not uniform. For instance the black peat is much deeper in the center and on the east side than on the west. The surface of the clay tends to dome up over the deepest point and the deposit is thicker over the west edge of the depression than the east.

The use of the bog surface as a datum of reference may be questioned. One gets the impression of a perfectly level surface in crossing the bog in any direction and all evidence accumulated suggests no reason to expect the contrary. Levels run six hundred feet out upon the open bog at the southeast end indicated a perfectly level surface. Although the outlet where the stream leaves the bay was found to be 3.6 feet below the level determined for the southeast end, the bog surface rises steeply from this outlet. At a point on the bog only 150 feet back of the outlet the average of 20 readings taken at random showed a rise of 1.5 feet in that short distance.

THE VEGETATION

The entire bog area is covered with a dense growth of shrubs throughout, in part as an understory in bog forests but dominating as such over the larger part of the bog. On much of the bog the shrubs are relatively low, from three to four feet, forming an open "pocosin" which includes roughly the central and southern portion of the bog and overlies the deepest part of the peat deposit. This will be designated the low shrub community in the following discussion. Contiguous with this on three sides, east, west, and north, is a dense growth of similar but taller shrub vegetation, the tall shrub community, averaging from twelve to fifteen feet. This community is exceedingly difficult to penetrate and one must cut his way through to make any headway at all. Throughout both of these areas in which the shrubs dominate there is a liberal scattering of widely spaced pocosin pines, *Pinus serotina* Michx. Toward the east and west sides and over the whole north end of the bog, trees dominate the vegetation. On the east is a strip of white cedar, *Chamaecyparis thyoides* (L.) B. S. P., on the west the bay forest community, and at the north end a forest of pocosin pine. In each of these the understory of shrubs is very dense but not quite so impenetrable as the tall shrub vegetation of the open part of the bog. Along the narrow bog margin where the peat and the sand meet there is another distinct community of trees and shrubs. *Sphagnum* is present throughout although nowhere in great abundance (see figure 3).

The communities are rather distinctive in their composition although certain species are conspicuous elements of some or all of them. For instance *Pinus serotina* and *Smilax laurifolia* L. are universally present, although the former assumes a position of dominance in the forest at the north end while the latter reaches its maximum development in the densest part of the tall shrub, where it very effectively ties the mass together with its large, long, thorny stems.

The low shrub and tall shrub are alike in composition, the latter being simply a later stage in the uninterrupted development of the former. The low shrub community is in general poorer in species. Certain herbaceous plants, specifically *Pteridium latiusculum* (Desv.) Hieron., *Sarracenia purpurea* L., and *Andropogon glomeratus* (Walt.) B. S. P. are entirely confined to this community. Elsewhere herbs are conspicuously absent except along the margin. Especially abundant and contributing as much as anything to the physiognomy of the community is *Zenobia cassinefolia* (Vent.) Pollard. *Chamaedaphne calyculata* (L.) Moench. and *Clethra alnifolia* L. are also both largely limited to the more open areas, the former becoming the dominant species locally. The presence of *Smilax laurifolia* is impressive, its scattered plants adding immensely to the tangle of the community. *Clethra* is the least abundant.

The taller shrub community represents less disturbed portions of the shrub bog and consequently a somewhat more mature stage in the development of the vegetation. Here there is a greater variety of species than in the low shrub community. The principal shrubs roughly in order of their contribution to the composition of the tall shrub community are as follows: *Ilex lucida* (Ait.) T. and G., *Smilax laurifolia* L., *Pieris nitida* B. and H. (locally dominating), *Zenobia cassinefolia, Ilex laevigata* (Pursh) Gray, *Kalmia angustifolia* L., *Lyonia ligustrina* var. *foliosiflora* (Michx.) Fern., *Itea virginica* L., and a scattering of *Amelanchier oblongifolia* (T. and G.) Roemer, *Aronia arbutifolia* (L.) Ell., and *Viburnum nudum* L. Small trees of *Acer rubrum* L., *Magnolia virginiana* L., and *Persea pubescens* (Pursh) Sarg. are very abundant.

The bay forest represented by a narrow strip along the west side is relatively poorer in species. Here *Acer rubrum* and *Magnolia virginiana* are dominant. *Vaccinium australe* Small is the principal understory shrub. Seedlings of *Acer rubrum* are abundant. The less common elements are *Persea pubescens, Ilex lucida, Itea virginica,* and *Smilax laurifolia.*

The white cedar forest is very poorly developed on this bog. It occurs as small, isolated stands along the east side and as small clumps out toward the center. Fire has recently destroyed some of them. The tall shrub bog grows intimately up against each stand and forms impenetrable thickets between them. The principal species associated with the white cedar is *Pieris nitida.* Such white cedar forests, their origin and successional status, have been described in an earlier paper (Buell & Cain 1943).

The pocosin pine forest at the north end occurs on a relatively thin layer of peat overlying the broad, gently sloping sandy shelf. The pines are large and closely enough spaced to produce a definite pine-dominated community. The understory is made up of large shrubs and small trees of the species which characterize the tall shrub community described above.

The bog margin community growing where the peat thins out to the coarse sandy soil of the surrounding upland includes a variety of shrubs not occurring, or if so very rarely, upon the bog proper. These are as follows: *Myrica cerifera* L., *Gordonia lasianthus* L., *Azalea atlantica* Ashe, *Vaccinium crassifolium* Andr., *Cyrilla racemiflora* L., *Ilex glabra* (L.) Gray, *Pieris mariana* (L.) B. and H., and *Nyssa biflora* Walt.

DISCUSSION

Jerome bog represents an ancient lake that has been filled in with a peat deposit. Its basin is one of a large number of such elliptical depressions (Melton and Schriever estimate about 1500 while Johnson believes there must be tens or even hundreds of thousands) on the coastal plain of the Carolinas. Many of the smaller ones may never have contained permanent lakes. A very large proportion of them did and most of these are now filled with peat and support very much the same vegetation complex as Jerome bog. Several lakes in various stages of being filled in are still present in the vicinity. The process by which these lakes are being filled in has already been described (Buell 1939). The peat which is accumulating in these lakes today is a black, mucky deposit similar to that in the upper levels of Jerome bog. The color of this deposit is the result of the fires that occur frequently on the surrounding bog, the fine charcoal washing into the lake and settling along with the unburned plant fragments. The upper foot of the black peat may represent peat partially burned in situ, for peat fires often occur in the coastal plain bogs. However, since all but the top layer of black peat has a liberal mixture of pollen and unburned fragments it seems most probable that, with the possible exception of this top foot, it represents a subaqueous deposit. That this is so is further indicated by the greater depth of the black peat in the center and the east portion of the bog compared with the west side where the brown peat occurs within two feet or less of the surface. The "Carolina bay" lakes fill in most rapidly on the west side, slowest on the east, so that the bog lakes of today lie off center on the east side. With this in mind, the distribution of the black and the brown peat suggests that when fires first became common on the coastal plain, i.e., probably either with the advent of man upon the scene or at a time of a shift to a drier climate, Jerome bog was a lake with but a marginal bog. It might well have appeared as Little Singletary Lake immediately south of it appears today (see figure 4) or any other of the bog lakes in the vicinity. It is also clear that the coastal plain has never been completely free from fire during the entire history of the bog, since small amounts of charred fragments are found even to the bottom of the brown peat.

As far as the present vegetation is concerned there is no question that fire is and has been for a long time the dominant factor concerned in the control of the communities. Fire-scarred pine trunks and charred stumps of fallen trees are common. The universal distribution of the underlying black peat testifies to a long-continued addition of charcoal to the accumulating deposit. Yet certain physiographic features of the bog are correlated with the present distribution-pattern of the communities.

The shrub communities overlie, in general, the deepest parts of the peat deposit extending from the south end out toward the center and the east side (fig. 3). This represents the path of the most frequent and most severe fires. The prevailing wind is southwest. The probable source of most fires is in the vicinity of the nearest habitation just west of the south end of the bog. The low shrubs occupy the area most commonly swept by the fires. The tall shrubs represent merely an area that has received less recent ravages by fire and as such a later stage in the uninterrupted natural succession on the bog.

The location of the white cedar forest is to be explained by a fire of sufficient intensity to have created an open seed bed required by the cedar (Buell & Cain 1943). They do indeed occupy an area where occasional fires from the southwest end might be expected to reach their greatest intensity.

The bay forest along the west side demonstrates fairly well what the tall shrub would ultimately lead to were fires to be kept out. This forest is located on the west where by virtue of being on the side from which the prevailing winds come it is protected from the most intense fires. Any fires which pass through it, fanned by the southwest wind, could not have first reached the full intensity attained after being driven through great masses of highly inflammable shrubbery. It is noticeable too that the black peat forms a thinner layer here than elsewhere along the east-west profile.

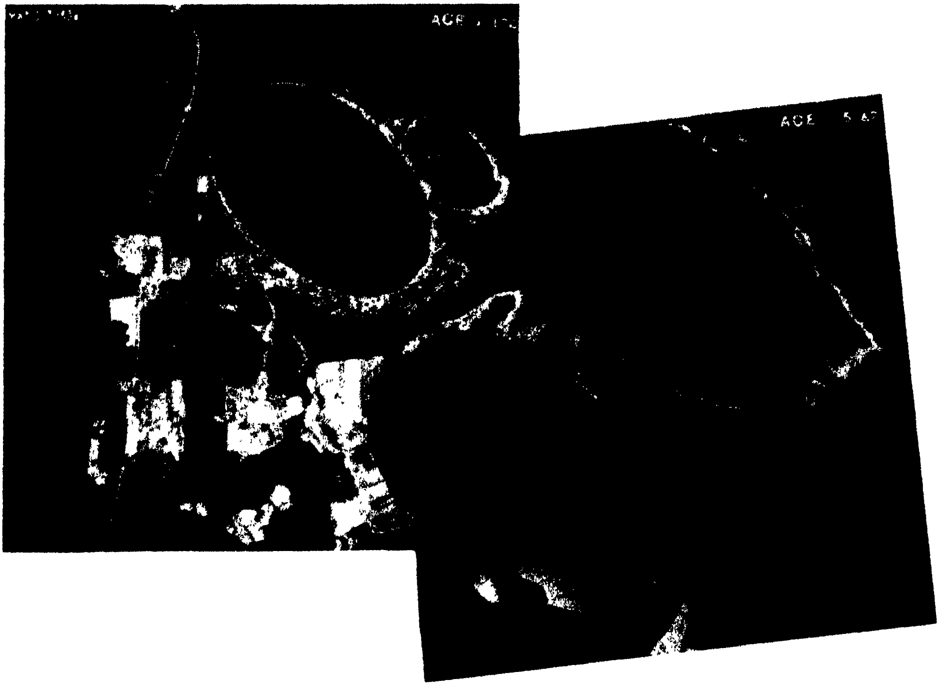


FIG. 4. Aerial photograph composite showing Jerome bog toward the northwest. Little Singletary Lake lies in the south central part of the area. Its bog margin is widest at the northwest end. Other "Carolina bays" both larger and smaller dot the area. (Photo by Agricultural Adjustment Administration.)

The pine forest at the northwest end occupies that portion of the bog underlain by the broad, gently sloping shelf upon which the peat deposit is thin. It is like the tall shrub community in composition with the exception of the abundance and size of the pines. The pines find conditions more favorable here than where the peat is deeper, a situation which may not be related to the peat depth alone. They are larger and are numerous enough so that the aspect is that of a forest compared with the open shrub bog with its scattered trees. Were fires to be kept out, this, like the tall shrub community, would become a broadleaf bay forest, since small trees of sweet bay, swamp bay, and maple are present throughout.

The climax forest on the bog is a broadleaf bay forest. In the study of the successional role of southern white cedar in this part of the state it was found that the cedar does not replace itself in the natural course of succession (Buell & Cain 1943). *Persea pubescens*, the swamp-bay, is the tree most capable of thriving in the intense shade of the cedar forest. That this extremely shade tolerant species, common throughout most of Jerome bog, would ultimately become the dominant tree of a climax bay forest seems extremely likely.

SUMMARY

1. Jerome bog occupies a "Carolina bay," one of a very large number of elliptical depressions on the coastal plain of the Carolinas. This basin is found to be deepest in the center with a trough continuing southward to an abrupt rise at the southeast end. At the northwest end is a broad, gently sloping shelf.

2. The deposit which has accumulated in this ancient lake basin consists of white clay in the deepest part, overlain by brown peat with scattered bits of charred fragments and, above this, black peat containing a high proportion of fine charcoal. The latter represents either the period since the advent of man bringing frequent fire or a drier climate, or both.

3. Fire holds the succession back so that much of the bog is in shrubs, and more severe burnings make occasional generations of southern white cedar possible locally. With fire protection the natural course of succession throughout would lead to a bay forest dominated by swamp bay *Persea pubescens*. The southern white cedar forest and the pocosin pine forest are merely subclimax types.

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THE EFFECT OF COLCHICINE AND ACENAPHTHENE IN COMBINATION WITH X-RAYS ON PLANT TISSUE—II[1]

MICHAEL LEVINE

MATERIALS AND METHODS

Root-tips on the bulbs of *Allium cepa* var. "Yellow Globe" were selected for this study. These were picked for their approximate uniformity of size and freedom from bruises and fungus infection. In one set of experiments, 18 bulbs of *Allium cepa* var. "Brigham Yellow Globe" sent to me by Dr. Henry A. Jones, U. S. Department of Agriculture, were used. These varied little in size, weight, and color. The bulbs used in the winter and early spring germinated promptly when set in water, but the dormancy of the summer crop was broken by exposure to low temperature (2°–5° C.) for 10–15 days. There were 15 sets of experiments, in each of which from 6 to 40 onions were used. Each set was started with a much larger number of bulbs than was actually used, for a small number were discarded during the first days of germination because of their failure to produce a satisfactory number of roots. After being weighed and recorded, the bulbs were placed on the mouths of cylindrical bottles of 240 ml. capacity filled with tap water. The water was changed daily and the bulbs washed in running water for a minute before they were returned to the jars.

In general, these plants were kept in water for 3–12 days before they were transferred to similar jars filled with an aqueous solution of 0.01 per cent colchicine in tap water. In preparation for irradiation after the colchicine exposure, the roots were washed in running water and placed on an inverted cardboard box, the bottom of which was perforated with 7 holes, each large enough to cradle a bulb. The bulbs were inverted so that the leaves or leaf ends were inserted into the holes and the root ends exposed to the air. The bulbs were then surrounded by walls of moist filter paper to prevent drying.

The x-ray machine employed delivered 95–133 roentgens per minute during the different exposures made. The voltage was 200 KV, 25 MA with a filter of 0.5 mm. copper and 3 mm. aluminum. The distance from the target varied for a given set of onions from 42 to 67 cm. Irradiations were made in single exposures with a total of 900r, 1500r, or 3000r. The actual exposure

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[1] The first paper of this series appeared in Bull. Torrey Club 72: 563–574.

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time varied from 11¼ to 30 minutes. The time consumed by the irradiation varied from 17 minutes to 40 minutes. The non-x-rayed onions in a given experiment were removed from their cylinders for a period equal to that consumed for irradiation and precautions were taken with these also to prevent drying. The position of each bulb under the x-ray machine was then recorded, although the portal of the x-ray machine was open and no cone was used, so that the field was considered to be evenly covered by the x-rays. In several experiments, colchicine was replaced by acenaphthene. Cylinders similar to those used for colchicine were filled with a saturated solution of this substance. The wet roots were then gently powdered with acenaphthene crystals. Many of these adhered to the roots even after they were placed in water. Root-tips of treated and control onions were fixed at definite intervals in Bouin's, Carnoy's, and in Flemming's weak solution. The material was imbedded in paraffin and sections from 5 μ to 7½ μ in thickness were made. Flemming's triple stain and Heidenhain's iron-haematoxylin were used. Brilliant results were obtained with safranin counterstained with light green dissolved in oil of cloves.

COLCHICINIZED ROOT-TIPS OF THE ONION

Root-tips of *Allium cepa* exposed to colchicine have been studied by a number of investigators. Havas (1937a), Kostoff (1938a), Levan (1938), Mangenot (1938a,b), Shimamura (1939a), and others showed that colchicine causes hypertrophy of seedling parts as well as roots. While these swellings were referred to as "tumors," a modifying word like "colchicine" might be added to separate this type of growth from plant overgrowths such as crown-gall, potato wart, club-root, and possibly other plant hyperplasias.

A series of studies were made in this laboratory on concentrations, and it was found that the most appropriate was approximately 0.01 per cent, because it produced swellings after 24 hours that made it possible to gauge macroscopically the effects of irradiation.

The effect of the solution was then studied to determine the time required to produce root-tip hypertrophies, their behavior in prolonged exposures to colchicine, and their reaction on return to water. Three sets of preliminary experiments were made with 18 onions. These bulbs germinated in water at room temperature in 24 hours, and at 48 hours each bulb showed from 2 to 8 roots measuring from 1 to 2 cm.; at 5 days there were from 8 to 35, measuring from 1 to 4 cm. in length. On the eighth day the average number of roots per bulb was 30. Nine of these bulbs were placed in 0.01 per cent colchicine and the remainder left in water as controls. In 18–24 hours, small swellings began to appear just above the root-tips. At the end of 48 hours the tips were definitely swollen, measured 1–2 mm. in diameter, and were pointed at the extreme apex. Roots that had been formed just before immersion in the colchicine were transformed into swollen bulbous or club-like structures.

Continued exposure produced no decided increase in the size of these hypertrophies. The return of the bulbs to water after more than 200 hours in colchicine caused these roots to resume growth in 3–4 days; the growth started at the distal portion of the hypertrophy. Root-tips treated with colchicine were fixed after immersion for 6, 18, 24, 36, 48, 72, 96, 120, 144, and 200 hours, and at various times after their return to water.

These preliminary experiments were further made the basis for determining the time at which the metaphase stage in cell division appeared in greatest numbers, so as better to adjust the time when irradiation would be most effective. Although the hypertrophies were greatest at the 48th hour, cytological preparations showed that the greatest number of metaphases occurred earlier, confirming a report from this laboratory (Levine & Gelber 1943) that onion root-tips exposed to 0.01 per cent colchicine produced the maximum number of metaphases at about 24 hours.

Untreated onions were not uniform in leaf development and the colchicine solution alone seemed to have no effect on leaf growth.

Microscopic studies proved that the concentration of colchicine used was in itself not destructive to the cells, and roots exposed for as long as 200 hours exhibited only a reduction in the size of the meristematic zone. The extreme tip atrophied and many of the cells contained deeply stained homogeneous nuclei. Median longitudinal sections of such roots showed that the cells were hypertrophied but the zone ot elongation remained inactive. There were areas of cellular activity that apparently represented secondary root meristems. The cells in these roots had few, if any, mitotic figures. The central or plerome cylinder of cells contained well differentiated nuclei and large vacuoles, while those in the periblem or mid-region and dermatogen or outer zone of cells contained large irregular nuclei, some of which were densely stained and undifferentiated. Small areas of destruction appeared to be due to the colchicine. In these cells, the walls were densely stained with the safranin, the cytoplasm was plasmolyzed, and in some there appeared to be fragments of densely stained granules possibly of nuclear origin. Cells in the branch root initials appeared quite normal, with a number of nuclei in mitosis, although the exact stages were not to be definitely established. The cells were embryonic in nature, with large, densely stained nuclei. When returned to water, the root-tips resumed growth and the bulbs produced a number of new roots.

The root-tips of the control onions grown in water for the same periods appeared normal. A small number of cells were found in all stages of nuclear and cell division.

THE GROSS EFFECT OF COLCHICINE AND 900 ROENTGENS

In a series of 6 preliminary experiments, the effect of a single dose of x-rays of 900r on colchicinized root-tips of bulbs of the "Yellow Globe" var.

of *Allium cepa* were studied. One hundred and thirty bulbs were grown in fresh tap water from 3 to 12 days. Eighty-two were then colchicinized for 24, 48, 72, 120, 135, and 140 hours. Thirty-two others were irradiated and of that number 20 were colchicinized. There were 3 or 4 irradiated colchicinized bulbs in each of the 6 experiments. The controls, 98 in number, consisted of non-x-rayed colchicinized bulbs and others that were neither x-rayed nor colchicinized. In these experiments, the gross effect of the colchicine-treated root-tips were contrasted with those that were colchicinized and x-rayed. The ability of the colchicinized, hypertrophied root-tip to resume growth when returned to water gave a ready ocular demonstration of the effectiveness of the colchicine-x-ray treatment. When the colchicinized bulbs were returned to water, the distal portion of the bulbous tip resumed growth, leaving the swelling behind it. The irradiated colchicinized root-tips behaved differently as described in detail in the report that follows.

Of the bulbs selected for colchicine and irradiation studies 12 were immersed in colchicine for 120 hours after a five-day period of germination. Five bulbs were irradiated with 900r and immediately thereafter all were returned to water. The gross differences were studied between the colchicinized-x-rayed root-tips and those that were treated only with colchicine. All the roots of the colchicine-x-ray group appeared alive but for the presence of an occasional flaccid, water-soaked one, yet no outgrowth had taken place at the root-tips (fig. 1). Eight days after their return to water the colchicine controls produced extensive outgrowths from the bulbous tips showing no impairment of the meristem at the tip of the hypertrophy (fig. 1, bulb 12). The short swollen roots clustered around the bulb appear to have elongated slightly (bulbs 3, 7) but no definite outgrowth followed. The short bulbous root-tips on the colchicine controls (bulb 12) also failed to resume growth after the bulbs were replaced in water. This difference in behavior between the short and long roots has not been explained.

After germination for five days, 15 bulbs were exposed to colchicine for 72 hours, then irradiated with 900r and finally returned to water. Five days later, these bulbs had a small number of flaccid roots among the healthy long ones (fig. 2) which showed no evidence of having resumed growth. The bulbs that were not irradiated (fig. 3) underwent characteristic recovery with the formation of secondary roots. The roots of another group of 24 onions in this series of experiments were exposed to a similar concentration of colchicine for 48 hours. They were similarly irradiated and returned to water. Eleven and one-half days after the treatment there was an unquestionable resumption of growth of the swollen root-tips (fig. 4). These colchicine-x-rayed bulbs showed root extension of approximately 0.5 cm. Daily measurements of the length of the roots, however, showed the growth to be slow and suggested an elongation process rather than one due to cellular proliferation.

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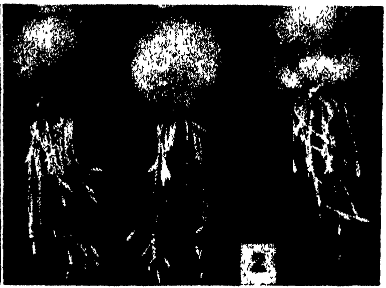
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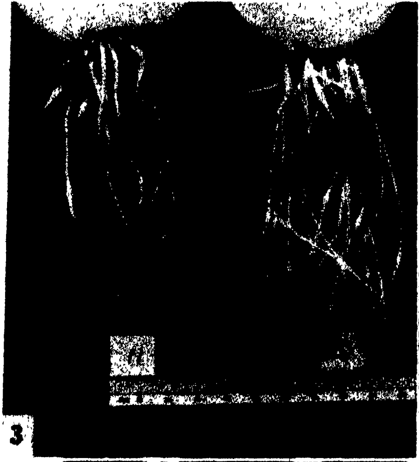
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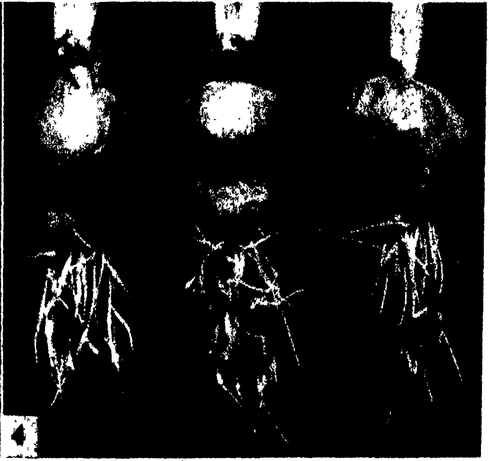
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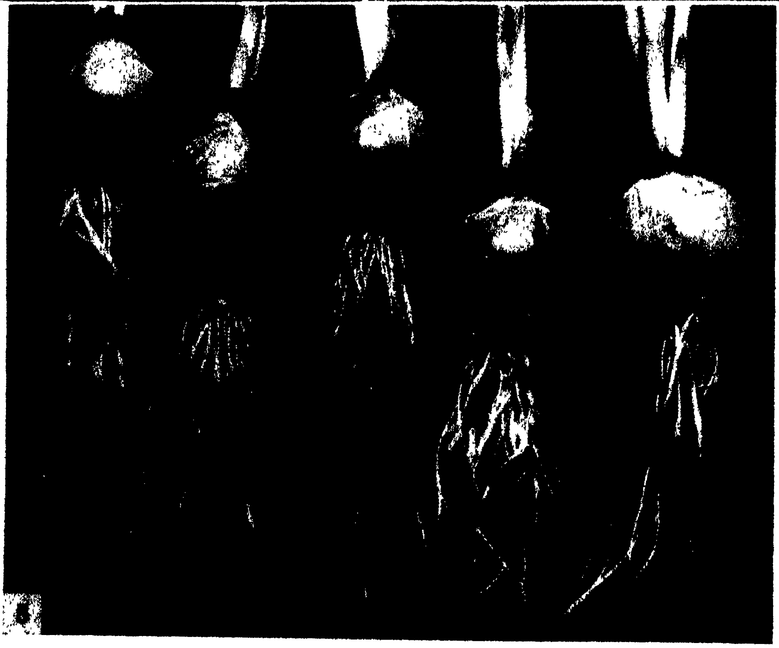
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Growth ceased after the sixth or seventh day. Comparison with the controls indicated clearly that growth had occurred in the roots which were treated only with colchicine (fig. 5). The outgrowth in the control was more slender than the portion of the root above the hypertrophy. Roots without hypertrophies, apparently new roots, had developed from the bulbs on their return to water. Secondary roots were formed, many of which arose from the hypertrophied portion of the root.

The significance of these results made it necessary to further test the effects of the irradiation on the 48-hour-colchicinized root-tips. In this test 30 bulbs were used, and after a germination period of six days the bulbs were colchicinized for 48 hours, irradiated with 900r, and then returned to water. These were studied daily. The results confirmed the findings observed above. Bulbs colchicinized only and returned to water underwent the usual recovery with active growth from the hypertrophied root-tips. Long tenuous secondary roots were frequently developed. The control non-colchicinized bulbs that were kept in water for nine days and were x-rayed simultaneously with the colchicinized bulbs showed little effect after their return to water. The roots appeared to be active, the tips were normal and not twisted, a phenomenon observed after exposure to larger doses of x-rays. There was, however, a temporary arrest of growth.

Root-tips that were colchicinized for 24 hours and irradiated with 900r grew after they were returned to water. Those that were colchicinized for 135–140 hours and irradiated reacted like those that were irradiated after 120 hours exposure to colchicine.

These experiments show that exposure to 900r has a temporary retarding effect on growth of root-tips of the onion, but that when it is preceded by exposures to colchicine for more than 48 hours, complete inhibition of growth is attained without causing immediate death. Root-tips exposed to colchicine for 48 hours followed by 900r, become impaired in growth with complete exhaustion of growth 5–7 days after their return to normal conditions.

CYTOLOGICAL CHANGES INDUCED BY COLCHICINE AND 900R

Colchicine for 24 hours and 900r. Colchicinized and x-rayed roots were selected at random for microscopic examination from all the bulbs that were

Explanation of figures 1–5

FIG. 1. Bulbs exposed to colchicine for 120 hours; irradiation 900r; returned to water after treatment for 8 days. Bulb 12 not irradiated. ×0.6. FIG. 2. Bulbs exposed to colchicine 72 hours; irradiation 900r; 5 days after their return to water. ×0.75. FIG. 3. Bulbs from same series not irradiated, colchicinized for 3 days; 5 days after their return to water. × 0.25. FIG. 4. Bulbs exposed to colchicine for 48 hours; irradiation 900r; 11½ days in water after treatments. × 1. FIG. 5. Bulbs colchicinized for 2 days and then returned to water for 11½ days; not x-rayed. × 7.

The photomicrographs were made on W. W. Panchromatic M. plates in a Zeiss 35 cm. camera. The objectives used were Zeiss 2a, 10, 20, 90; eye piece Homol 1; bellows extension 50 to 100 cm.; filters K_2 and B.

subjected to these agents. Sections through the periblem were studied principally because these better exposed the largest number of dividing cells.

The untreated control root-tips kept in water for 15 days showed normal cellular structures with a moderate number of nuclear and cell divisions. Sections of root-tips made from the bulbs colchicinized for 24 hours and exposed to air for a period of 30–40 minutes (fig. 7), during which time other bulbs were x-rayed, presented no marked or recognizable influence of this treatment except for the colchicine-induced metaphases. In the calyptrogen or root cap of these root-tips, the nuclei were compact bodies, homogeneously stained with Flemming's triple stain. The dermatogen cells contained metaphase stages and occasional late telophases were observed with good spindles. There was evidence of fusion of chromosome masses, while the nuclei in the resting cells were well differentiated and the chromatin was stained brilliantly with gentian violet. The chromatin granules were distinct and appeared to be sharply defined as if some contraction or accumulation of the material had occurred. The cytoplasm in these cells was stained a faint orange. In these preparations there was evidence of a concentration of the granular elements in the cytoplasm, forming a close reticulum. There was no evidence of nuclear or cytoplasmic injury.

Under higher magnification (fig. 8), the chromosomes showed longitudinal splitting with few instances of chromosome clumping. The 24-hour-colchicine-treated root-tips irradiated with 900r were fixed two hours after their return to water. In these sections there was evidence of marked clumping of the chromosomes in the metaphase stage, although chromosomes occasionally separated from the fused masses could be recognized as being longitudinally split (fig. 9). A number of prophases appeared in these preparations which were apparently normal. A detailed study of the colchicinized and x-rayed root-tip cells is shown in fig. 10. Ring-shaped chromosomes such as reported by Marquardt (1938) and Sax (1941) were not infrequent.

The x-ray control plants not treated with colchicine but irradiated with 900r (fig. 11) were grown in water for 13 days 3 hours, irradiated and returned to water for 2 hours and 40 minutes before fixation. These tips showed few metaphases and less marked chromosomal aberrations than those treated with colchicine and x-rays. The clumping of the chromosomes was not strongly developed and split chromosomes were not infrequently found.

Root-tips that were colchicinized for 24 hours and irradiated with 900r grew after they were returned to water. Microscopically, these tips fixed eight days after their return to water showed that the cells were active and viable (fig. 12). The subsequent history of these roots was not followed in detail. Sections of the untreated control roots were normal; mitoses were frequent without any apparent abnormalities, in spite of their exposure to water for 21 days.

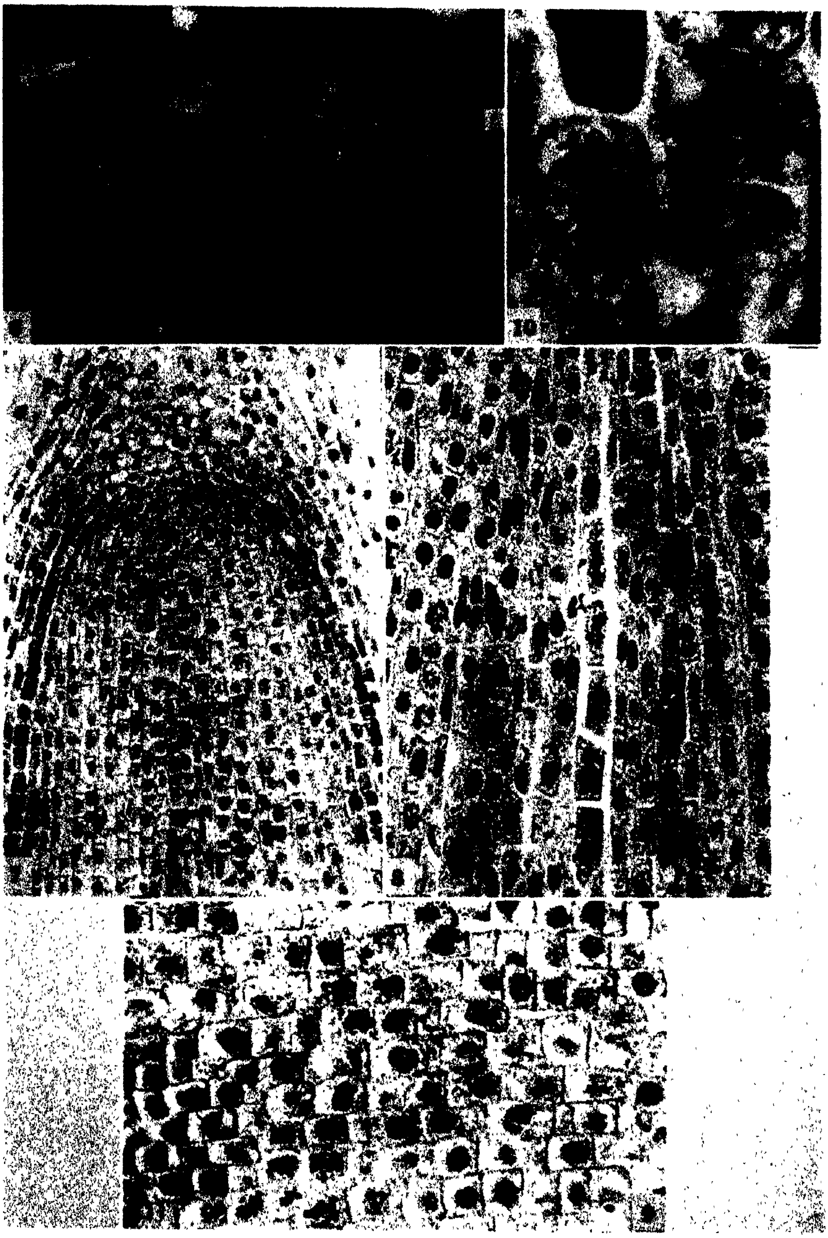
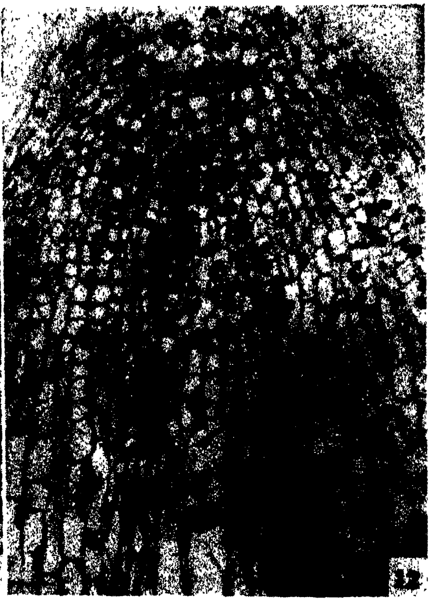


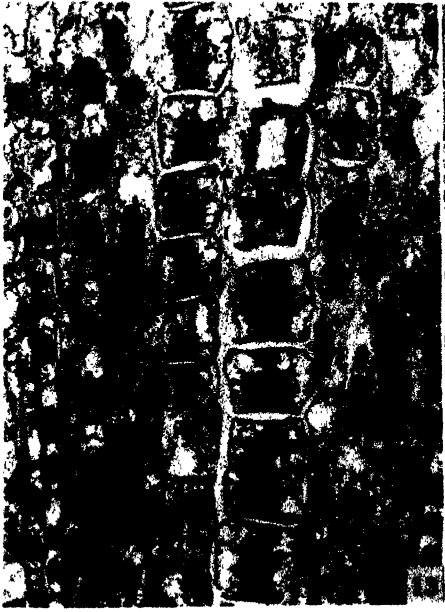
FIG. 6. Bulbs 21, 29, 30 exposed to a saturated solution of acenaphthene for 48 hours; irradiation 900r; returned to water 5 days. Bulb 9, no irradiation. × 0.6. FIG. 7. Exposed to colchicine 24 hours; to air 30–40 minutes. × 250. FIG. 8. Section of root-tip after 24 hours in colchicine. × 500. FIG. 9. Root-tip exposed to colchicine for 24 hours; irradiation 900r; fixed 2 hours after their return to water. × 500. FIG. 10. Selected cells from root-tip shown in figure 9. × 1800.

Colchicine for 48 hours and 900r. Root-tips exposed to colchicine for 48 hours, followed by irradiation with 900r, were fixed for microscopical examination at various intervals after their return to water. These were compared with the root-tips that were x-rayed or colchicinized only and returned to water for various periods of time. Serial sections of root-tips were made. These tips were fixed immediately after their removal from 44–51 hours exposure to colchicine before irradiation. In the root-tips colchicinized for 48 hours the cells of the elongation zone had become wider and only slightly longer and so had produced the characteristic bulge or swelling of the root-tip. The number of metaphases was fewer than after the 24-hour treatment and the chromosomes appeared to be fused and contracted, while fragmentation occurred. These observations were in accord with those of Levan (1938), Shimamura (1939a) and others. There appeared to be a number of masses of gentian-violet-staining material in some cells, most frequently but two. Their subsequent behavior could be interpreted as giving rise to polyploid lobulate nuclei.

The chromosomes in these preparations frequently appeared indistinguishable from those subjected to irradiation and suggested the effect described by Dustin and his students. The resting nuclei were densely stained. The cells were vacuolate and there appeared to be a more intensely staining granular structure in the cytoplasm. The peripheral cells, however, were vacuolized and the cytoplasm had a tendency to be stained more densely. The return of these colchicinized bulbs to water caused the root-tip to recover, as shown by its renewed ability to grow. The meristematic tissue, however, appeared to be less voluminous and the outgrowth from the bulbous tip resulted in a somewhat attenuated structure. Under certain conditions the entire bulbous root-tip became elongated before the root-tip resumed growth. Sections of root-tips from the same bulb made 24 hours after their return to water showed recovery from the metaphase stasis. Normal telophases occurred although there was some evidence of contracted, deeply stained nuclei and possibly dead cells. Sections of roots from the same bulbs in water 72 hours after their removal from colchicine showed various figures in mitotic stages of development and seemed apparently normal.

Bulbs treated in colchicine for 44–48 hours and irradiated with 900r were studied shortly after the x-ray exposure. The root-tips fixed one hour and 35 minutes after their return to water at the end of irradiation contained elongated chromosome masses (fig. 13), and highly vacuolized cells, some of which enclosed lobulate nuclei. The cytoplasm in these preparations appeared to be reticulate with densely staining granules lying in the meshwork. These observations were made repeatedly in several groups of bulbs studied. Sections of root-tips from the same bulbs 48 hours after the colchicine and x-ray treatment (fig. 14) showed slightly elongated, hypertrophied cells, although





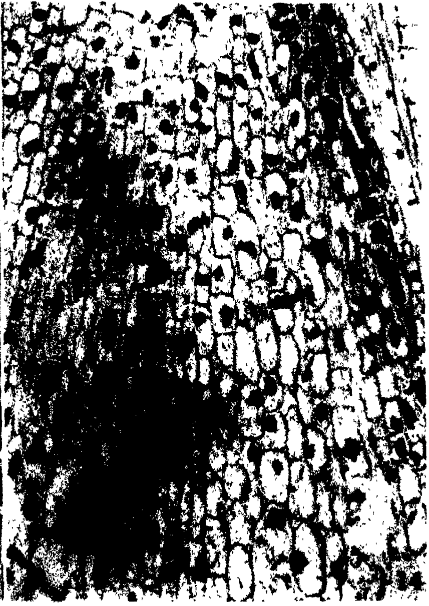


FIG. 11. Root-tip irradiated with 900r, fixed 2 hours and 40 minutes after its return to water. × 250. FIG. 12. Root-tip treated the same as that shown in figure 9; fixed 8 days after return to water. × 250. FIG. 13. Portion of root-tip exposed to colchicine 48 hours; irradiation 900r; fixed from water 1½ hours after irradiation. × 500. FIG. 14. Section of root-tip treated as in figure 13; fixed from water 48 hours after treatment. × 250.

they appeared to be arranged in regular tiers. The nuclei were irregular in shape; some were homogeneously stained and indicated injury. Many ruby-red-stained bodies appeared, apparently nucleoli; usually two were found in each cell. In the later stages, in which the roots were returned to water for 80 hours, there appeared to be recovery. Nuclear divisions were in progress and the intense cytoplasmic vacuolization had now disappeared (fig. 15). There was evidence in these preparations that the chromosome number had increased, but no chromosome counts were made. The outgrowths from these colchicinized-irradiated root-tips after their return to water had reduced but normal meristems; division stages were not abundant. The active cells were stained like normal meristematic tissue. The formation of secondary root meristems was unaffected by the colchicine-x-ray treatment. It seemed that these structures were formed after the effects of these stimuli were no longer present; few secondary roots were observed to develop.

Colchicine for 72 hours and 900r. Root-tips exposed to colchicine for 72 hours produced new outgrowths from the bulbous tips which grew uninterruptedly (fig. 3). Microscopic studies of the tips (fig. 16) made 4 days after their return to water showed a meristematic region of normal cells with a small number of nuclei in division. The periblem cells were vacuolate and some occasionally contained giant nuclei. These aberrant cells were in the hypertrophied portion of the root.

The colchicine-irradiated root-tips made no outgrowth from the bulbous tip 96 hours after their return to water (fig. 2). The cells in these root-tips were large and vacuolate (fig. 17) with large homogeneously stained nuclei. The plerome cells were slightly elongated, and the nuclei though somewhat large contained no distinct chromatic granules. The nucleoli were well differentiated and took the safranin brilliantly. The periblem cells showed evidence of injury and maturity. The vacuoles were large and the nuclei slightly lobulated. Growth in these cells was not followed beyond the fifth day after their return to water.

Colchicine for 125 hours and 900r. An examination of the outgrowths removed from the bulbous tip (fig. 3) which were produced by an exposure to the colchicine for 125 hours and then returned to water for 90 hours showed cytological structures similar to those of normal root-tips with approximately a normal distribution of mitotic figures (fig. 18). The area of the meristematic region appeared small.

The root-tips exposed to colchicine for 125 hours and irradiated with 900r were examined microscopically after having been returned to water for 90 hours. The cells were hypertrophied (figs. 1, 19); only the terminal portion, where the meristem would normally be, showed a small collection of cells with densely stained nuclei; no calyptrogen was present. The periblem

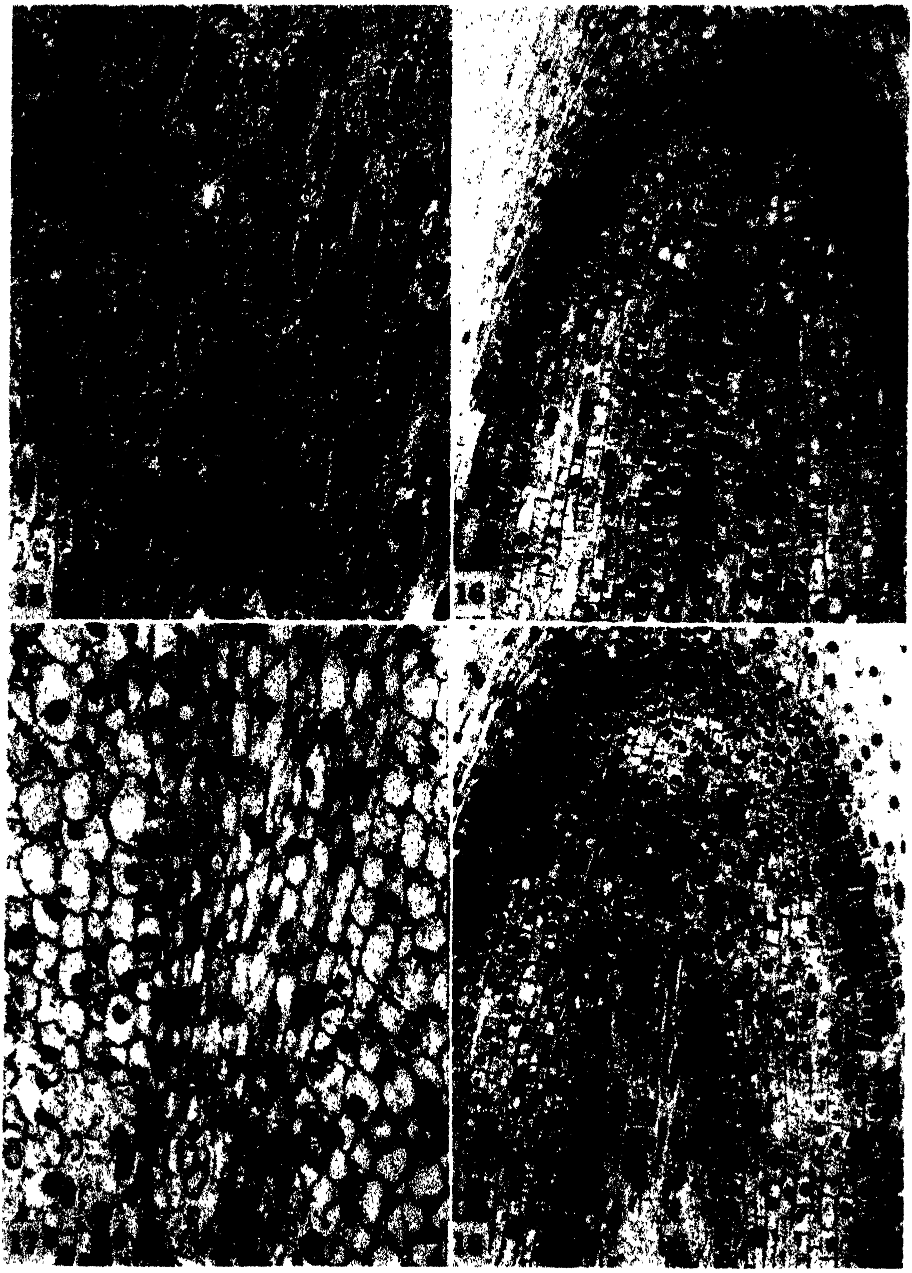


FIG. 15. Part of root-tip treated as in figure 13, fixed after being in water for 80 hours. × 500. FIG. 16. Section of root-tip after return to water for 96 hours; exposed to colchicine for 72 hours. × 250. FIG. 17. Section of root-tip after return to water for 96 hours; exposed to colchicine for 72 hours followed by 900r. × 250. FIG. 18. Root-tip exposed to colchicine for 125 hours, fixed 90 hours after return to water. × 250.

cells were large in size with irregularly shaped nuclei which were well differentiated. Evidence of nuclear lobulation occurred. The cytoplasm was strikingly fibrillar in nature and formed a reticulum which was well preserved by the fixative. The cells were not dead but evidently showed the influence of marked earlier disturbances. There were no outgrowths from these swellings eight days after their return to water.

Colchicine for 140 hours and 900r. Root-tips immersed in colchicine for 140 hours and followed by irradiation (900r) were fixed approximately one and one-half hours after their return to water. The meristematic area in these roots was reduced to empty cells, although a thin layer of deeply staining tissue below a degenerated root-cap was always present. There were some active cells surrounding the plerome, although division stages were not seen. The viability of these roots was represented principally by some few cells. Those in the plerome area were large with extensive vacuoles, and the nuclei seemed polyploid, for many were lobulate; while other cells were binucleate. The densely stained portions of the root appeared to be made of necrotized cells. Many cells in the periblem contained large vacuoles, while many were empty.

The root-tips colchicinized for 140 hours and irradiated with 900r, when examined microscopically after having been kept in water for 48 hours (fig. 20), contained active viable cells about the lower portion of the plerome. A densely stained necrotic tissue surrounded this cluster of cells in which the nuclei were lobed though densely stained. Large nuclei in hypertrophied cells were also present. Many of the cells had normal cytoplasm; some had a delicately reticulated cytoplasm while others were large and empty. The periblem cells now contained only a few nuclei; most of them were necrotized, with fragments of deeply stained bodies. Root-tips from this series, kept 8 days in water after irradiation, were flaccid. The upper portions of these roots were alive, however, for secondary root initials were present although none seemed to emerge. Irregular spiral thickenings of the vessels were noted in the central cylinder, while the cells of the secondary root meristems were in various stages of nuclear division. The irradiation effects were entirely absent at this period. Root-tips taken from bulbs exposed to colchicine for 140 hours, but with the irradiation treatment omitted, gave evidence of normal recovery of growth as described above. The upper part of these roots developed normal secondary branches. The roots at this stage of the experiment were in water before and after colchicine, a total of 24 days.

These results show clearly that root-tips exposed to 0.01 per cent aqueous solution of colchicine for 140–200 hours suffer no permanent effect on growth. When returned to water they recover, and new primary and secondary roots are formed.

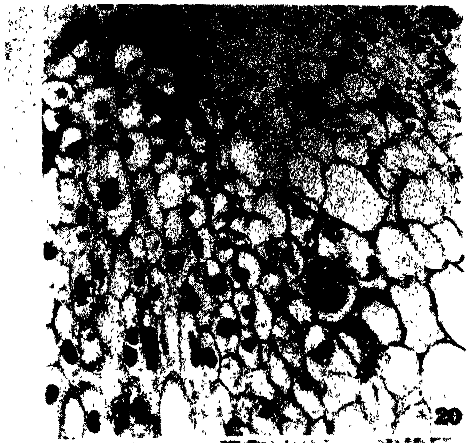
The colchicinized root-tips irradiated with 900r show that the length of colchicine exposure influences recovery; long exposures (72–140 hours) followed by irradiation completely inhibit growth. The colchicinized controls make new growth after their return to water. With shorter colchicine exposures (48 hours and less) growth is still inhibited, yet the bulbous tips produce outgrowths from their distal portions. Obviously the inhibiting factor is not a function of the irradiation (900r), which had only a temporary retarding effect, but of the combined result of both agents. These gross observations are well supported by microscopic evidence. The short colchicine exposures followed by irradiation left unimpaired meristematic cells, which were capable of producing new growth. The long colchicine exposures coupled with 900r inhibited and impaired the fundamental tissues and no outgrowth occurred from the hypertrophies. Irradiated (900r) non-colchicinized root-tips failed to show the gross and microscopic changes induced by the application of both agents.

THE GROSS EFFECT OF COLCHICINE WITH 1500R OR 3000R

These investigations were made on a strain of selected onions of the "Brigham Yellow Globe" variety of *Allium cepa* together with bulbs of the "Yellow Globe" variety culled from the open market. These onions were germinated for 7–8 days after they had been chilled for 12–14 days to break their dormancy. The roots of these bulbs were then immersed in an aqueous solution of 0.01 per cent colchicine for various periods. Of the colchicinized onions some were x-rayed and returned to water. A number of bulbs were x-rayed only and an equal number were treated with neither colchicine nor x-rays.

In one experiment 18 bulbs of the "Brigham Yellow Globe" variety were used. These bulbs weighed from 58 to 94 g. and germinated uniformly eight days after they were placed in water; the number of roots which each produced varied. Leaves developed on all bulbs with only slight differences in number and in size. These bulbs were divided into two groups and six bulbs of each were set in the colchicine solution while three remained in water. After an exposure to colchicine for 48 hours five bulbs were irradiated with 1500r; two bulbs were not colchicinized but were irradiated only. In the other group, five bulbs were colchicinized and exposed to 3000r and two non-colchicinized bulbs were included in this exposure. One colchicinized and two untreated bulbs served as controls in each set.

The roots of these bulbs were studied at various intervals after treatment. The colchicinized bulbs (fig. 21, bulbs 2 and 7) that were given 1500r and 3000r respectively showed clearly 9 days after their return to water that growth of the meristem had been inhibited. The non-colchicinized bulbs irradiated with 3000r (bulb 13) showed considerable root injury. The roots



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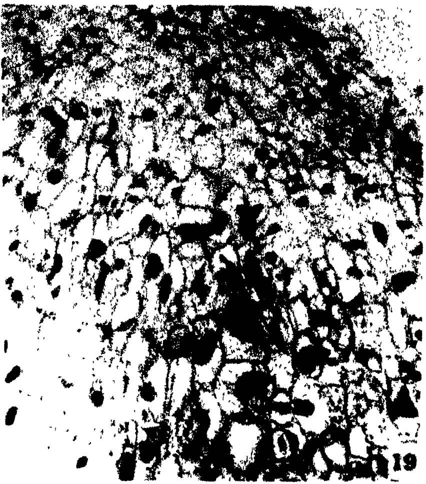

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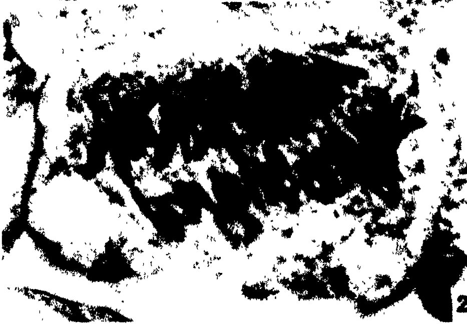

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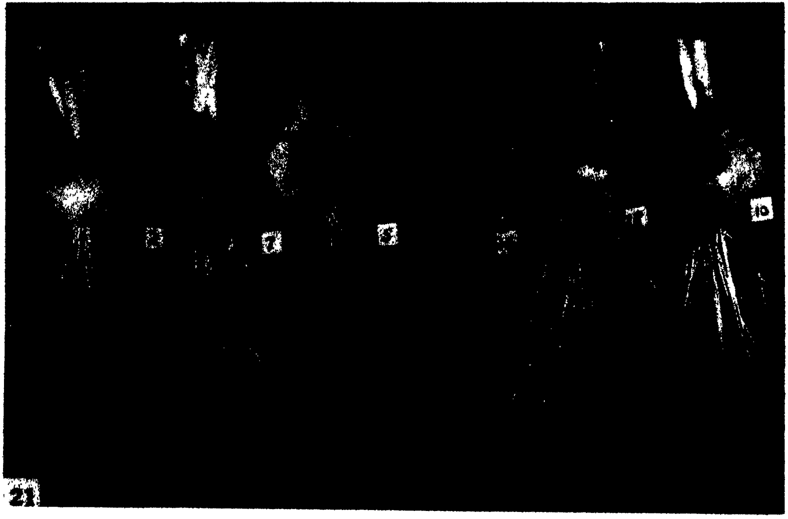

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FIG. 19. Root-tip in colchicine for 125 hours; irradiation 900r; fixed after 90 hours in water. × 250. FIG. 20. Root-tip treated in colchicine 140 hours; irradiated with 900r; fixed after 48 hours in water. × 250. FIG. 21. Effect of colchicine and irradiation on root-tips. Bulb 7, colchicine and 3000r; 13, 3000r only; 2, colchicine and 1500r; 5, 1500r only; 18, colchicine only; in water 12 days after colchicine and x-rays; bulb 10, water only. × 0.6. FIG. 23. Root-tip cells treated as in figure 22. × 1800.

of bulbs (bulb 5) which received only 1500r showed the characteristic bending or twisting of the root-tips and fewer necrotic ones, while bulbs (bulb 18) which were colchicinized only showed outgrowths of the hypertrophied root-tips with an abundance of secondary roots. The water controls (bulb 10) showed evidence of continued growth even though bulb decay had occurred.

The roots from some bulbs selected at random from each of these series were counted and measured before and after treatment. These were removed after their return to water for 19 days to study better the effect produced by the treatment. The control bulbs grown in water for 29 days had a number of long roots with many secondaries. Some of the small roots appeared water-soaked and necrotic. The root-tips on the rest were firm and appeared to be active. The roots that were irradiated with 1500r had been in water 10 days before and 19 days after treatment. The effects of the x-rays seemed to be confined to the root-tips, where slight twisting and bending were noted. There was evidence of growth, but no secondary roots appeared. The roots which were irradiated with 3000r showed more marked distortion of the root-tips of the long roots, while the short ones showed no such evidence. The irradiated root-tips appeared viable and capable of growth. The bulbs that were colchicinized only and returned to water produced a large number of new roots with an abundance of secondary ones; these developed after the bulbs were returned to water, giving further evidence that colchicine had no permanent growth-inhibiting effect.

Roots examined from the bulbs that were colchicinized and irradiated with 1500r 19 days after treatment showed a very limited extension of the bulbous tip on a few of the roots. Here the inhibition of growth induced by colchicine and x-rays was practically complete. Similar gross effects were obtained with longer exposures to colchicine (72 hours) and less irradiation (900r). Roots of colchicinized bulbs irradiated with 3000r were completely arrested in growth. A number of the roots were water-soaked and necrotic. No new roots were formed and no secondary roots were visible. The x-ray dosage which completely inhibits growth seems to be slightly above 1500r when combined with an exposure to 0.01 per cent colchicine solution for 48 hours.

It appears that the 48-hour-colchicinized bulbs were more vulnerable to the x-ray treatment even though the time of exposure occurred when the number of dividing cells had passed the peak of their reaction to the drug. The "colchicine tumor" furnished a means of demonstrating growth inhibition and helped to point out clearly that the colchicine facilitated the action of the x-rays in permanently arresting growth and destroying tissue. Microscopic studies of these roots together with daily measurements furnished further evidence on this point.

CYTOLOGICAL CHANGES INDUCED WITH 1500R OR 3000R

Microscopic studies of the root-tips of the "Brigham Yellow Globe" variety were made before and at various periods after exposure to colchicine. The root-tips fixed in this series from samplings taken from all bulbs before treatment showed abundant karyokinetic activity. In root-tips exposed to colchicine for six hours there was an accumulation of metaphases in which the chromosome masses seemed to be radiomimetic. The cells in the dermatogen were deeply stained and poorly differentiated. The root-tips exposed for 12, 18, 24, and 48 hours contained an increasing number of metaphases except in the last group. Root-tips of this variety of onion colchicinized for 48 hours and studied 24 hours after their return to water recovered from the colchicine effect (fig. 22). Characteristic giant cells with lobulate nuclei and normal nuclear and cell divisions were found. The hypertrophy of the root-tips was marked, yet the cells were definitely oriented in regular tiers as shown in this section and described earlier by Levan (1938), Shimamura (1939a), Mangenot (1939), and others. Yet many of the sections seemed aberrant because of the difference in size of the cells. The cell arrangement, however, was so regular that no analogy between this hypertrophy and the crown-gall disease or malignant growths of animals could be made. The "colchicine tumor" does not fall into any category of tumor growth.

It has been shown by Levan (1938) and others that polyploidy occurs in colchicine-treated root-tips, and large numbers of chromosomes have been counted. Increasingly large masses of distinct, clearly differentiated, apparently normal chromosomes were observed in the cells of the same root-tip (fig. 23). Polyploid cells were frequently found in these "colchicine tumors," in crown-gall, and in tumors of animal and man (Levine 1931). Polyploidy does not appear to be the sole criterion for malignancy. The causes of this increased chromosome-number in overgrowths are not known, though it may be ascribed to some disturbance in the spindle mechanism. It appears that in the polyploid cells of colchicine-treated root-tips the chromosomes may separate in anaphase regularly and equally. The reconstructed nuclei, although sometimes lobulate, go through a normal mitosis when the influence of the drug is removed. The radiomimetic effect induced by the colchicine disappears. Isolated chromosome masses may be reconstructed to form small or irregularly shaped nuclei which account for the irregularity in the size of the cells. These features are constant characteristics of malignant growths and

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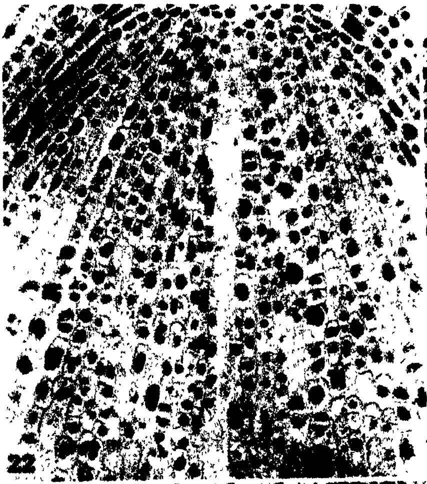
Explanation of figures 22, 24–26, 28

FIG. 22. Root-tip colchicinized 48 hours; fixed after 24 hours in water. × 250. FIG. 24. Root-tip exposed to 1500r; fixed 120 hours after treatment. × 250. FIG. 25. Root-tip exposed to colchicine for 48 hours; irradiation 1500r; fixed from water 120 hours later. × 250. FIG. 26. Root-tip exposed to colchicine for 48 hours, irradiation 3000r; fixed from water 24 hours later. × 250. FIG. 28. Bulbs exposed to colchicine for 18½ hours followed by irradiation with 1500r; 9 days after return to water. Bulbs 26, 27, 28, colchicine and x-rays; 30, colchicine; bulbs 6 and 32, x-rays. × 0.6.



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are consistently perpetuated in these growths, while in the colchicine-treated tissue the normal and polyploid cells seem to persist in subsequent cell generation and assume normal behavior under normal conditions.

Non-Colchicinized Irradiated Roots. Normal roots irradiated with 1500r and returned to water for 24 hours contained no nuclear division figures as observed by Sax (1941). The peripheral cells of the root-tips were densely stained and the contracted nuclei appeared to be in the resting stage. Irradiated root-tips taken from the same bulbs 120 hours after their return to water resumed growth, as witnessed by the number of division stages (fig. 24). The resting nuclei appeared normal, yet some had more than two nucleoli. The nuclei had assumed a central position in the cell and the nucleoli appeared to be isolated by a clear area of nucleoplasm. Macroscopically the roots appeared normal.

Colchicinized for 48 hours with 1500r or 3000r. Root-tips colchicinized for 48 hours and then irradiated with 1500r, and returned to water for 120 hours, showed (fig. 25) elongated old cells with large contracted, undifferentiated nuclei, from which cytoplasmic strands radiated. Here obviously, the colchicine effect has been augmented by the injurious influence of the x-rays. Control roots irradiated with 3000r and examined 24 hours later contained no division figures. The nuclei, in the dermatogen and outer layers of the periblem somewhat irregular in outline, appeared as densely stained undifferentiated bodies. The plerome and inner layers of the periblem had a well differentiated cellular structure. The root-tips colchicinized for 48 hours, irradiated with 3000r, and examined 24 hours after their return to water were also lacking in division stages (fig. 26). The cells in the periblem and plerome had many contracted nuclei which were heavily stained. The nuclei in the peripheral cells of the root-tips appeared densely stained. Root-tips from this series examined 120 hours after their irradiation showed marked destruction of the peripheral cells (fig. 27). The calyptrogen was represented by a few elongated enucleated cells. The periblem showed contracted densely staining nuclei with little cytoplasm. The pericycle about the plerome formed regular tiers of cells in which the nuclei were densely stained and undifferentiated. Some of these cells, however, had a granular densely stained cytoplasm while still others appeared to be considerably plasmolyzed. The plerome had formed a number of layers of cells in which poorly differentiated nuclei were present. The cytoplasm was sparse and the vacuoles large. No division figures were found in any of the numerous serial sections made of these roots. It was obvious that these roots had been severely damaged, although the early development of this injury was not visible.

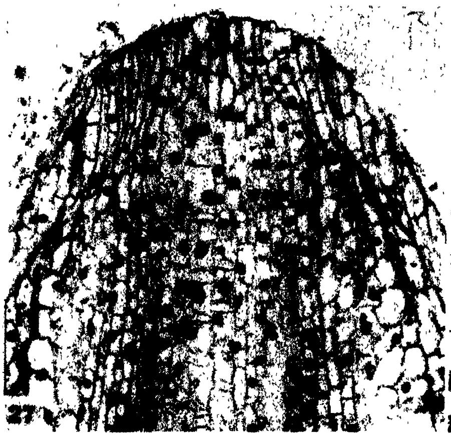
This microscopic study shows rather conclusively that the combined effects of colchicine and x-rays are more effective in reducing the rate of growth and bring about earlier necrosis under the conditions of these experiments than x-rays alone. No root markings were successfully made to show the difference in effect produced by the x-rays on normal and colchicinized root-tips. However, the cytological evidence and a study of the growth of the root-tips (tables 5, 6) under various treatments show that the colchicinized root-tips are more vulnerable to x-rays than those non-colchicinized.

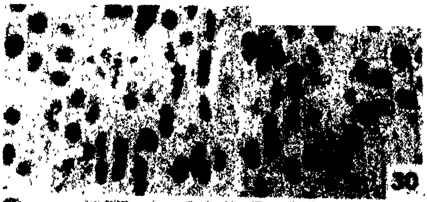
EFFECT OF SHORT EXPOSURES TO COLCHICINE

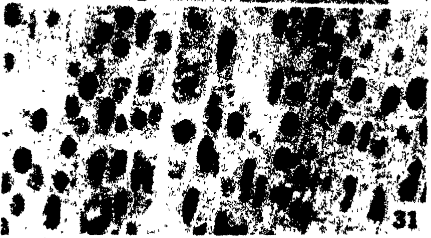
The fact that in onion root-tips exposed to colchicine for 48 hours irradiation with 900r or 1500r retarded and inhibited the outgrowths of the colchicine hypertrophies made it necessary to study the effects of irradiation on roots exposed to this substance for some periods shorter than and intermediate between 24 and 48 hours. Eighteen onions of the "Yellow Globe" variety were germinated in tap water for eight days and then exposed to 0.01 per cent solution of colchicine for 18½ and 36 hours to test the effect of x-irradiation of 1500r. A six-hour exposure to colchicine seemed too short to bring about the necessary toxic effects; while nuclear divisions were arrested and metaphases began to accumulate, no hypertrophies were produced and root measurements were necesary to determine the effect produced.

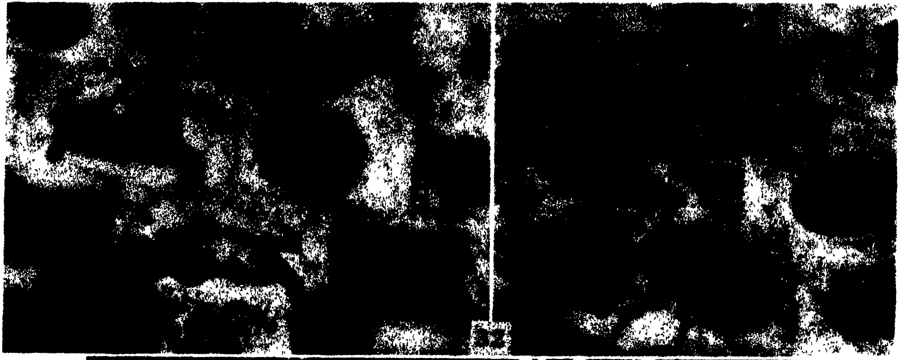
Fourteen bulbs were set in the colchicine solution. After 18½ hours a group of seven designated as "A" was returned to water. The remaining seven bulbs, group "B," were continued in colchicine for 17½ hours longer. At the end of 18½ and 36 hours, five bulbs from each group were irradiated with 1500r, and two bulbs not colchicinized were irradiated with each group. Photographic records were made at frequent intervals after they were returned to water. The colchicinized and x-rayed root-tips, nine days after their return to water (fig. 28, bulbs 26, 27, 28) resumed growth from the bulbous tips. The hypertrophies were small after this short colchicine exposure, nevertheless, they were recognizable and marked clearly the new growth after their return to water. When contrasted with the non-irradiated colchicinized roots (fig. 28, bulb 30) little or no difference was noted, except that the latter produced many secondary roots.

Root-tips irradiated only (fig. 28, bulbs 6, 32) showed only slight twisting of some of the root-tips. Those colchicinized and irradiated were not permanently affected in their ability to resume growth, yet 23 days after treatment these bulbs (fig. 29) presented some contrast with the earlier stages. At this time colchicinized-x-rayed bulbs (bulbs 26, 27, 28) showed only slight increases in the length of roots. Secondary roots were formed on the distal portion of some of the long primaries and some new roots had formed. The roots of the x-rayed bulbs (bulb 6) had increased slightly in length and in number. The colchicinized non-irradiated bulbs (bulbs 30, 31) produced many new roots, as well as long outgrowths from the hypertrophied root-tips. The colchicine appeared to produce no marked observable changes. In contrast with these results the longer colchicine exposures, 48 hours and









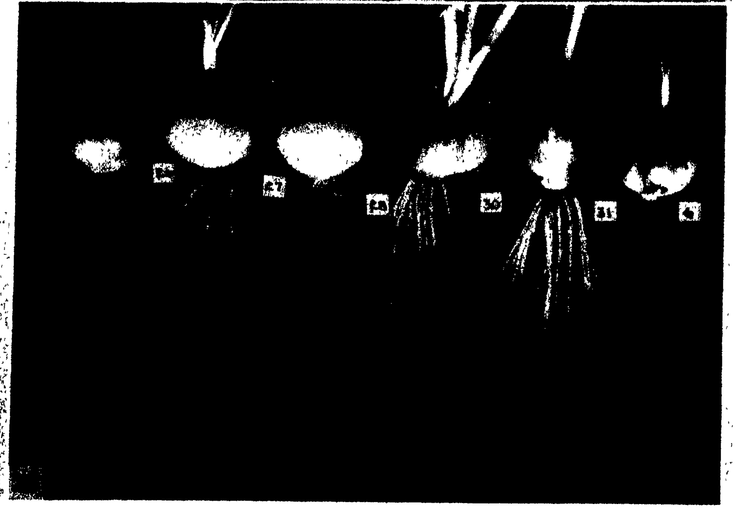


FIG. 27. As in figure 26; fixed 120 hours after irradiation. × 250. FIG. 29. Same as figure 28; 23 days after return to water. × 0.6. FIG. 30. Section of root-tip colchicinized 18½ hours. × 500. FIG. 31. Section of root-tip in colchicine for 18½ hours, irradiation 1500r. × 500. FIG. 32. Chromosomes and resting nuclei in root-tips as affected by colchicine and irradiation; treatment as in figure 31. × 1800.

more, followed by 1500r brought about nearly complete and permanent inhibition of growth.

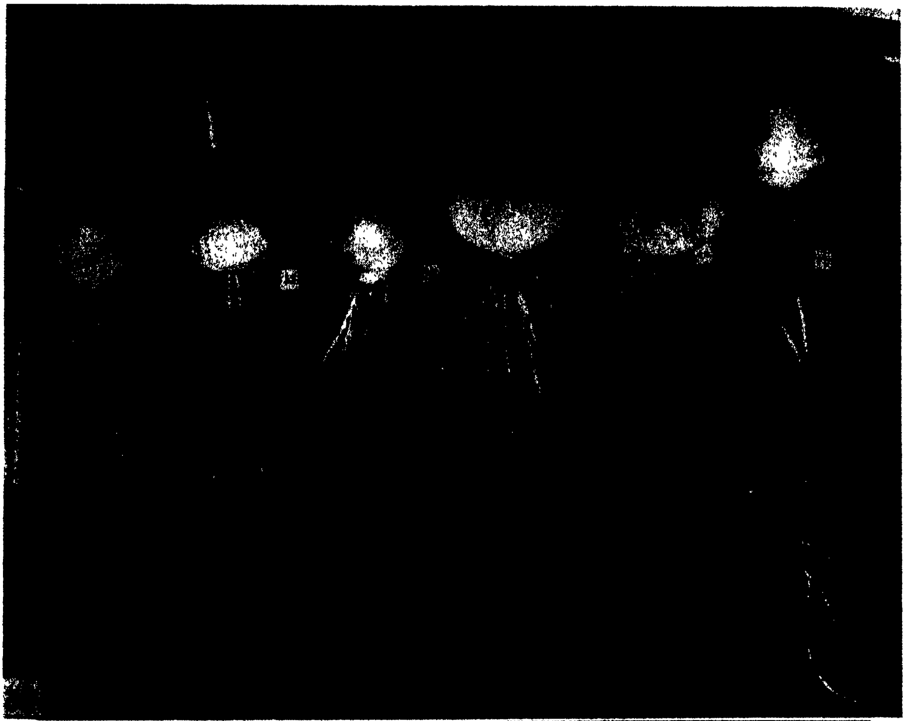
Microscopic sections were studied of roots taken from bulbs 26, 27, and 28 after 18½ hours exposure to colchicine and immediate fixing. The metaphase stages (fig. 30) were in abundance and confined principally to the periblem and dermatogen. Here many early prophases appeared and indicated marked growth activity. Sections of fixed material made 24 hours after the colchicine treatment showed normal cells, some of which were in prophase and telophase stages; while those root-tips which were colchicinized, irradiated, and immediately fixed showed the intensified clumping of chromosomes commonly seen in the primary stages of x-ray effects referred to above (fig. 31). The resting nuclei in some of the cells (fig. 32) showed the characteristic clear area about the nucleoli. The dividing nuclei consisted of longitudinally split chromosomes, chromosome fusions, and in some instances fragmentation.

It seems that while colchicine causes analogous cytological changes at 6, 12, 18, 24, and 48 hours of exposure, the longer exposures induce some microscopically unrecognizable alterations. These changes permit the cells to resume growth for a short period after the shorter exposures to colchicine followed by 1500r, but completely and permanently arrest the growth when the longer colchicine exposures are followed by the same x-ray dosage. This is evidence of the fact that the irradiation is not the sole factor that inhibits growth but that both agents supplement each other effectively.

In the colchicinized-irradiated root-tips 24 hours after treatment no division figures were found. The nuclei appeared to be contracted, yet beautifully differentiated with ruby-red bodies, apparently nucleoli, and numerous granules stained with gentian violet on a delicate reticulum. The nuclei appeared somewhat irregular in shape and resembled those described above.

Root-tips of bulbs irradiated only were studied immediately after the roots were irradiated with 1500r. The cytological changes of the division figures were less marked than in the colchicinized-x-rayed root-tips. Many of the resting nuclei were heavily stained. In the resting nuclei the chromatic material was concentrated near the nuclear membrane, leaving a clear area about the nucleoli. Some of the peripheral cells contained densely stained undifferentiated nuclei. The cytological structure of the root-tips fixed 24 hours after irradiation was normal but no division figures were seen. The arrangement of the chromatic material about the nuclear membrane was not marked but was evident in some cells.

At the end of this experiment, 31 days after irradiation, the roots of colchicinized and irradiated bulbs had increased only slightly in length. Some of the roots took on a dingy brown color. The roots which had been colchicinized only were growing vigorously, while roots that had been irradiated only had grown in an irregular manner so as to be apparently twisted at the tips.



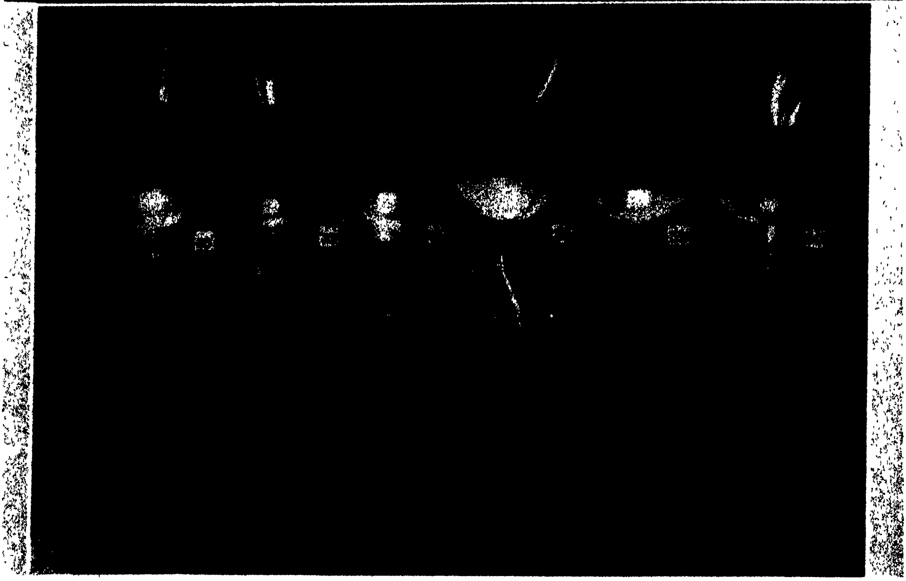
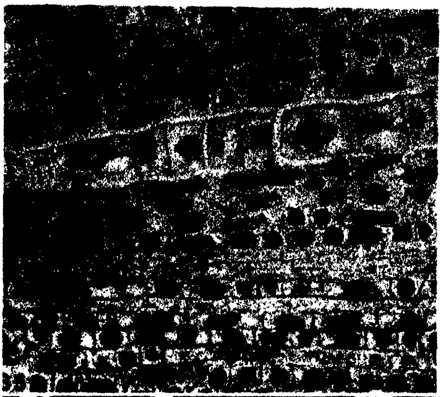
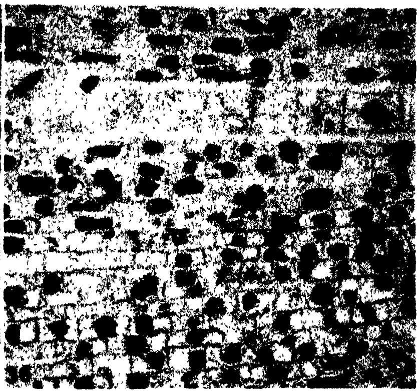
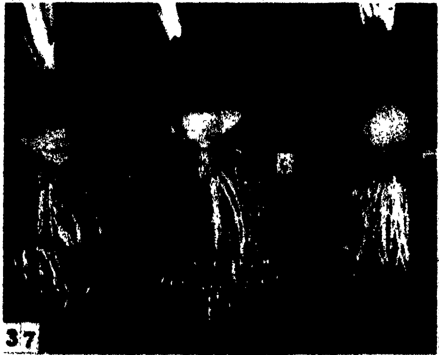
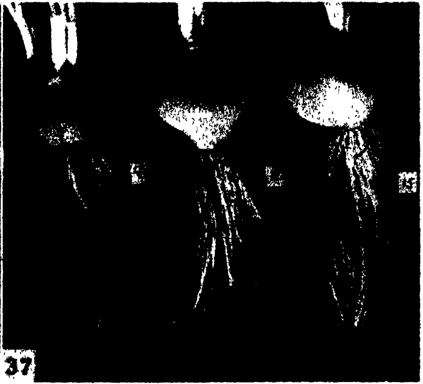


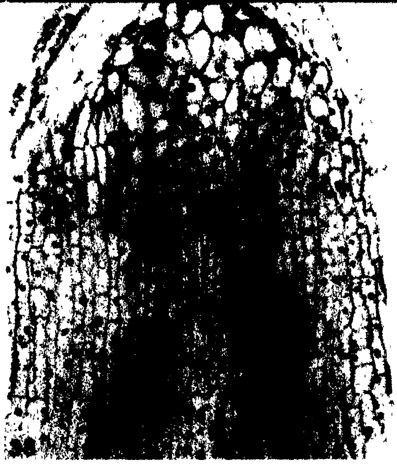
FIG. 33. Bulbs 33, 35, 36, exposed to colchicine for 36 hours; irradiation 1500r; bulb 38, colchicine only; bulb 40, irradiated only; bulb 17, water only; 8 days after water. × 0.6. FIG. 34. Same group as figure 33, 22½ days after their return to water; bulb 39, colchicine-treated only. × 0.6.











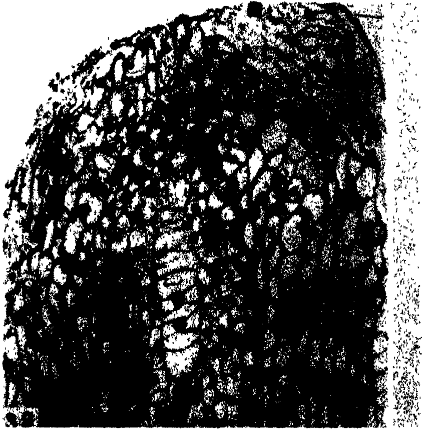
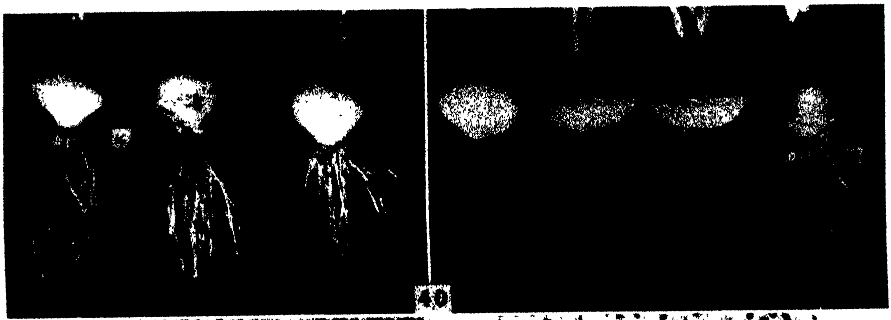


FIG. 35. Root-tip colchicinized 36 hours; fixed 24 hours after return to water. × 500. FIG. 36. Exposed to colchicine 36 hours; irradiation 1500r. × 500. FIG. 37. Bulb 3, colchicine 48 hours, irradiation 3000r; bulb 6, colchicine 2 days; bulb 13, irradiation 3000r, followed by water 6 days; bulb 11, acenaphthene 2 days, irradiation 3000r; bulb 9, acenaphthene 2 days, 6 days in water after treatment; bulb 15, water only. × 0.6. FIG. 38. Root-tip from bulb 11 (fig. 37) 2 weeks after irradiation. × 250. FIG. 39. Root-tip after exposure to colchicine for 48 hours; irradiation 3000r; returned to water for 2 weeks. × 250.



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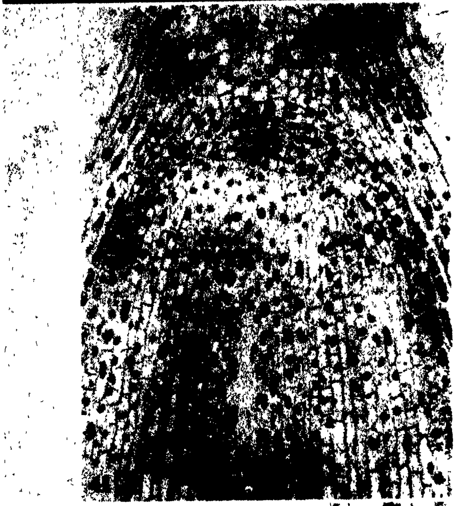

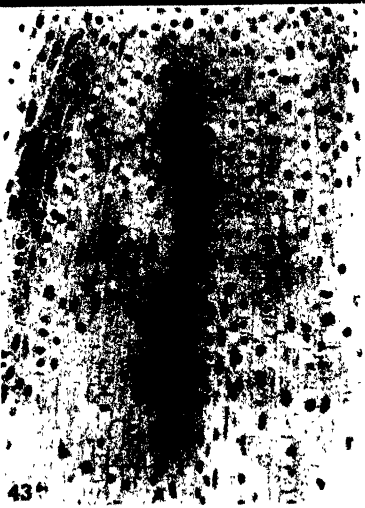

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FIG. 40. Bulbs 16, 18, 21, colchicinized for 2 days, exposed to 1500r, and returned to water for 6 days; bulb 23, exposed to acenaphthene for 2 days; bulb 25, exposed to acenaphthene for 2 days, irradiation 1500r; bulb 28, irradiation 1500r; bulb 29, untreated; 7 days after their return to water. × 0.6. FIG. 41. Root-tip from bulb 28 shown in figure 40, 4 days after irradiation. × 250. FIG. 42. Root-tips from bulb treated with acenaphthene for 48 hours. × 250. FIG. 43. Root-tip from bulb treated with acenaphthene and irradiation 1500r; 4 days after the treatment. × 250.

The "B" group included onions exposed to colchicine for 36 hours followed by irradiation with 1500r. Of this group (fig. 33), bulbs 33, 35, and 36 were colchicinized and irradiated; bulb 38 was colchicinized only; while bulb 40 was irradiated only and bulb 17 was not treated. The photograph shown as figure 33 was taken eight days after treatment.

The hypertrophied tips on the colchicinized irradiated group had grown slightly 8 days after their return to water in comparison with those (bulb 38) that were colchicinized only. The bulbs irradiated only had root-tips which grew with characteristic irregularity. Twenty-two days after their return to water (fig. 34) there appeared to be little change in the length of the colchicinized-irradiated roots. There were some flaccid, water-soaked roots, while no new roots appeared. The bulbs colchicinized only showed an extensive growth from the hypertrophied root-tips. The bulbs irradiated only showed some increase in root length and some new roots appeared.

It is obvious that the effects of colchicine and irradiation are more active when combined than when used singly. The irradiated plants studied are affected, but not so much as those that received the longer colchicine treatments. It appears that the optimum effect is attained when irradiations are combined with an exposure to colchicine of more than the 36 hours. The combination of 900r with 0.01 per cent colchicine for 72 hours or 1500r with 48 hours exposure to colchicine is most effective in arresting root growth without destroying the root.

There was no marked microscopic difference between these roots and those treated for 18 hours in colchicine. Serial sections of the root-tips 24 hours after the 36-hour exposure to colchicine showed many normal as well as polyploid cells (fig. 35). The prophase division stages were abundant; anaphase cells which appeared polyploid although not exceedingly hypertrophied were found here with numbers of contracted chromosomes. The colchicinized-irradiated root-tips (fig. 36) contained many resting cells which were densely stained. There was evidence of contraction of the chromatic network. The dividing nuclei had the chromosomal fusions typical of colchicine-irradiation treatments, which appeared to be somewhat more intense than the radiomimetic effects of colchicine alone. Of these bulbs, root-tips examined 24 hours after irradiation had no division figures, and the cells resembled those observed in the 18-hour colchicine irradiation group.

It appears that the longer colchicine exposures induced some non-recognizable toxic change, which makes the cells more susceptible to the irradiation. The fact that the greatest x-ray effect is induced after exposures to colchicine for more than 48 hours indicates that the action of the x-rays is independent of the nuclear division phase but is in some way dependent upon the influence exerted by the colchicine.

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MEDICINAL HERBACEOUS SPECIES IN THE NORTHEASTERN UNITED STATES

RALPH HOLT CHENEY

Economic botany, particularly in its food and materia medica phases (Godshall 1942; Merrill 1943), served the war effort directly in numerous ways. This paper is limited to those vascular plants which are potential sources of drugs in the northeastern part of the United States. These plants are of interest because they could be gathered annually to supply a part of the total amount of the therapeutic compounds used by the medical profession. Some of these botanic drugs are important medicinal agents and are not made synthetically. These species could also provide the basis for the establishment and subsequent genetic improvement of a cultivated crop not produced currently in the area surveyed. A considerable list of drug plants such as described by the author and others (Ballard, Cheney & Pokorny 1943) for the Brooklyn Botanic Garden, are displayed usually in municipal and institutional botanical gardens. In every such display, however, the number of individual plants of most of the species is so small that they could not serve effectively as a source of seeds or other parts for any extensive propagation of a drug crop. Even before the present world war, a Committee on Pharmacognosy and Pharmaceutical Botany of the National Research Council began an investigation[1] of the wild medicinal plants of the United States. One of the purposes of this survey was to tabulate the geographic distribution and abundance of naturally growing domestic sources of botanic drugs for reference in periods of national emergency. Although considerable data on the location, abundance, and some useful ecological information, had been compiled by the advent of the United States into the war, it was obvious that the magnitude of this task would make its value primarily one of a long term nature.

Early in 1941, it was my privilege to discuss, before the combined committees of the New York Academy of Medicine, the problem of drug plant sources and their availability in view of the drug shortages due to the effect of the war upon our normal importation. During the next two years some of the commercial companies increased their acreage of drug plants as much as one thousand per cent. The Federal Government has grown quinine seedlings (*Cinchona* varieties of the cultivated Dutch East Netherlands type) and distributed them for planting in proper ecological areas of tropical America. Moreover, the U. S. Cinchona Mission to South America reports (Steere 1945), in addition to the common quinine-producing species, an area in southern Colombia and Ecuador where the supposedly rare species, *Cinchona pitayensis,* is fairly abundant. Its bark yields 3% quinine sulphate. In addition, this mission reports the bark of another small tree, *Remijia pedunculata,* although not the genus *Cinchona,* also yields 3% quinine sulphate and is abundant in the eastern range of the Colombian Andes. Already the *Cinchona* bark quotas set up in 1942 by the U. S. Office of Foreign Economic Administration in an arrangement with the Andean governments have been exceeded. The Bureau of Plant Industry, cooperating with the Bureau of Narcotics, has information for the production of opium and suitable seeds to meet the morphine requirements of both the military and civilian needs of the U. S. (Sonnedecker 1943). Our northwestern States can supply, if commercial growers should fail, enough *Digitalis purpurea* L., to supply our demand.

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[1] "A Survey of the Wild Medicinal Plants of the United States—Their Distribution and Abundance 1937; with supplements. Compiled by the Committee on Pharmacognosy and Pharmaceutical Botany, Division of Biology and Agriculture, National Research Council. (Processed. Not for general distribution.)"

The author began an investigation in 1941 to determine the availability of herbaceous medicinal species occurring in the wild state and in nurseries, in the northeastern area of the United States. In spite of considerable field data on hand, it was impossible to tabulate in any great detail the local distribution of wild and cultivated medicinal species. Moreover, the literature reveals no standardized criteria for the determination of drug plant species, especially when non-official species were included. Therefore, it was decided that the study would attempt merely to *list* the herbaceous medicinal species in the area surveyed and to obtain *quantitative* data only on ten representative drug plants known to be utilized in current pharmaceutical preparations. The author (Cheney 1944) has made a preliminary report on these ten species, which were chosen from a list (Gathercoal 1941, 1942) involving a wide variety of therapeutic principles and plants typical of the several major ecological conditions existing within the area surveyed. Since these ten species were cultivated, their abundance in the approximating 2400 nurseries of the States involved indicated their availability for medical utilization during the present emergency. The eight States involved are New Jersey, New York, Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, and Maine. During the past four years, the majority of the nurseries which grow herbaceous plants, have been visited by the author in connection with his field trips or information was obtained by questionnaire. The ten selected drugs, with the species from which they are obtained, are shown in the accompanying table.

The wild herbaceous, medicinal species occurring in the northeastern area include actual and potential sources mostly of minor therapeutic signifi-

Botanical Origin	*Common Name*	*Part Used*	*Drug Name*	*Drug Status*[a]	*Medicinal Use*[b]
Aconitum napellus L.	Aconite or monkshood	Tuberous root	Aconitum	O	Cardiac & respiratory depressant, anodyne, antipyretic
Aloe vera L. (*Aloe barbadensis* Miller)	Barbadoes aloes or bitter aloe, Curaco aloe	Inspissated and dried leaf juice	Formerly Aloe & aloin Now Aloinum[c]	O	Cathartic, improve healing rate from X-ray burns
Atropa belladonna L.	Belladonna or deadly nightshade	Leaves & roots alkaloid	Formerly Belladonnae Radix & Belladonnae Folium. Now is Atropina	O	Anodyne, mydriatic, decreases secretions, relaxes smooth muscle in asthmatic spasms
Convallaria majalis L.	Lily-of-the-valley	Rhizomes & roots[d]	Convallaria	O	Cardiac stimulant, diuretic properties similar to digitalis but non-cumulative
Datura stramonium L.	Jimson weed or Jamestown weed	Dried leaves & flowering tops	Stramonium	O	Similar properties to Belladonna, dilates bronchioles in Asthma
Digitalis purpurea L.	Purple foxglove	Dried leaves	Digitalis folium or Foxglove	O	Cardiac stimulant, diuretic
Hyoscyamus niger L.	Black henbane	Dried leaves with or without tops	Hyoscyami folium or Henbane	O	Similar to Belladonna but chiefly a sedative in inflammatory conditions of genito-urinary tract, checks vesical spasm in urinary incontinence
Salvia officinalis L.	Garden sage	Dried leaves	Salvia or Sage	O	Condiment & carminative in flatulence
Urginea maritima (L.) Baker	Squill or sea onion	Bulb	White or Mediterranean squill or Scilla	O	White variety emetic, a nauseant expectorant in small doses & a cardiac drug in large doses
		Inner scales of bulb	Red variety	U	Red variety is emetic & rodenticide. (Rats cannot regurgitate)
Valeriana officinalis L.	Common or garden valerian	Rhizomes & roots	Valeriana	O	Supposed nervine, carminative, anti-hysteric, anti-spasmodic

[a] O = official; U = unofficial.

[b] The author wishes to acknowledge with grateful appreciation, the assistance of Benjamin L. Milana of the department of Materia Medica, Brooklyn College of Pharmacy, Long Island University, in the preparation of the data cited under Medicinal Use.

[c] Mixture of bitter pentosides, not an alkaloid.

[d] Flowers (& leaves) also have physiological action. They are unofficial as Convallariae flores.

cance. If not of major medicinal value, they are of interest from the viewpoint of their availability for plant breeding. The concentration of active therapeutic compounds can be accomplished as it has been done with *Aconitum* (Bonisteel 1943). The data presented should be of importance, not only for their possible collection for emergency utilization, but because they are elucidative on the possibility of developing certain species as the basis of a future drug source industry in this area which would protect us against shortages in the event of similar national emergencies.

The wild herbaceous species possessing medicinal value and growing naturally in general throughout the eight states—unless otherwise indicated—covered by this survey are shown in the table on pp. 64–70.

SUMMARY

With the exception of considerable numbers of plants of *Convallaria*, only a relatively few plants or a small quantity of seed is available of the ten cultivated species. One or more of these species is propagated by the growers of several states only to the following extent: in 14 per cent of the Connecticut nurseries, Maine 0, Massachusetts 40 per cent, New Hampshire 30 per cent, New Jersey 20 per cent, New York 20 per cent, Rhode Island 28 per cent, and Vermont 24 per cent. These percentages would be reduced very greatly if it were not for the inclusion of lily-of-the-valley and sage in this list. By less than 0.5 per cent of the nurseries a few plants were reported of *Atropa belladonna* L. (belladonna), *Colchicum autumnale* L. (colchicine), *Hedeoma pulegioides* (L.) Pers. (American pennyroyal), and *Urginea maritima* (L.) Baker (red squill). A more informative picture of the scarcity of the drug plant propagation of these ten species for which quantitative data were obtained may be shown by the tabulation cited below for the area surveyed.

Species	Conn.	Me.	Mass.	N.H.	N.J.	N.Y.	R.I.	Vt.
			per cent nurseries in which grown					
Aconitum napellus L.[a]	0	0	5%	5%	4%	12%	1%	8%
Aloe vera L.	0	0	0	0	0	0	0	0
Atropa belladonna L.	0	0	0	0	0.5%	0	0	0
Convallaria majalis L.	14%	0	40%	12%	12%	20%	2%	12%
Datura stramonium L.	0	0	0.5%	0	0	0.5%	0	0
Digitalis purpurea L.	0.5%	0	5%	5%	8%	8%	2%	1%
Hyoscyamus niger L.	0	0	0	0	0	0	0	0
Salvia officinalis L.	0.5%	0	30%	2.5%	8%	4%	1%	12%
Urginea maritima (L.) Baker	0	0	0	0	0	0	0	0
Valeriana officinalis L.	0.5%	0	20%	2.5%	12%	8%	2%	1%

[a] Much of the aconite was found to be *A. Fisherii*, not *A. napellus* L.

The *cultivation* of drug plant species by a few botanic drug companies has increased greatly since the advent of world war II. Otherwise, in com-

Botanical Origin	*Common Name and Habitat in Northeastern United States*	*Part Used*	*Drug Name*	*Drug Status*[a]	*Medicinal Use*
Acorus calamus L.	Sweet flag; marshes of lower altitudes	Peeled rhizome	Calamus	O	Carminative, aromatic bitter as stomachic stimulant
Agropyron repens (L.) Beauv.	Couch or dog-grass; fields & waste places	Rhizome & roots	Triticum	O	Demulcent, diuretic
Apocynum cannabinum L. var. *hypericifolium* (Ait.) Gray	Indian or Canadian hemp; moist banks with gravelly or sandy soil	Rhizome & roots	Apocynum	O	Cardiac stimulant (poison), (contains glucosides), diuretic
Aralia nudicaulis L.	Wild sarsaparilla; moist woodlands	Aromatic roots	Substitute for true Sarsaparilla	U	Alterative (Substitute for official Sarsaparilla)
Aralia racemosa L.	American spikenard or spignet; rich woodlands	Rhizome & roots	Aralia or spikenard	O	Alterative
Asarum canadense L.	Wild ginger or Canada snakeroot; rich rocky woods	Rhizome & roots	Asarum	O	Aromatic bitter, carminative
Caulophyllum thalictroides (L.) Michx.	Blue cohosh or papoose root; rich woods	Rhizome & roots	Caulophyllum	O	Antispasmodic, emmenagogue, oxytocic
Chelidonium majus L.	Celandine; waste places	Entire flowering plant	Chelidonium	U	Cathartic, diuretic, diaphoretic, expectorant
Chimaphila umbellata (L.) Nutt.	Pipsissewa or prince's pine; dry woods	Leaf	Chimaphila	O	Diuretic, tonic and astringent on mucous membrane of genito-urinary tract

[a] O = official; U = unofficial.

Botanical Origin	*Common Name and Habitat in Northeastern United States*	*Part Used*	*Drug Name*	*Drug Status*	*Medicinal Use*
Cimicifuga racemosa (L.) Nutt.	Black snakeroot or black cohosh; rich woods (not in northern N.E. range)	Rhizome & roots	Cimicifuga	O	Antirheumatic, uterine tonic (doubtful), possibly alterative
Coptis trifolia (L.) Salisb.	Goldthread; wet woods	Entire herb	Coptis	U	Bitter tonic
Cypripedium hirsutum Mill.	Showy yellow lady's slipper; cold swamps	Rhizome & roots	Cypripedium[b]	U	Nervine, antispasmodic
Cypripedium parviflorum Salisb.	Smaller yellow lady's slipper; bogs and swampy woods	Rhizome & roots	Cypripedium[b]	U	Nervine, antispasmodic
Cypripedium pubescens Willd.	Larger yellow lady's slipper; rich moist woods	Rhizomes & roots	Cypripedium[b]	U	Nervine, antispasmodic
Delphinium ajacis L.	Larkspur; fields & wet places (not in N. H. & Maine)	Seed	Delphinium	O	Parasiticide in pediculosis
Delphinium ajacis L. Var. *alba* Cheney	White larkspur; fields locally; east. Mass. (Cheney in Rhodora, 1925)	Seed	Probably contains same alkaloid "Adjacine," $C_{34}H_{48}O_9N_2 \cdot 2H_2O$, as the species with similar properties.		
Dicentra canadensis (Goldie) Walp.	Squirrel corn; rich woods	Tubers	Corydalis or Turkey Corn	O	Alterative in chronic cutaneous affections, tonic
Dicentra cucullaria (L.) Bernh.	Dutchman's Breeches; rich wooded hillsides	Tubers	Corydalis	O	Similar to above
Drosera anglica Huds.	Sundew; marly bogs	Entire plant	Drosera or Sundew	U	In proprietary remedies for bronchitis and cough

[b] Cypripedium is known also as American valerian and used as a substitute for valerian in hysteria.

Botanical Origin	*Common Name and Habitat in Northeastern United States*	*Part Used*	*Drug Name*	*Drug Status*	*Medicinal Use*
Drosera longifolia L.	Sundew; bogs and sandy shores	Entire plant	Drosero or Sundew	U	Expectorant
Drosera rotundifolia L.	Round-leaved sundew; peat bogs & wet sand banks	Entire plant	Drosero or Sundew	U	Expectorant, Alcoholic extraction of this species and *Thymus vulgaris* L. is a preferred homeopathic remedy for whooping cough (pertussis)
Dryopteris Filix mas (L.) Swartz.	Male fern; rocky woods	Rhizome & stipes	Aspidium	O	Taenicide, vermifuge
Dryopteris marginalis (L.) A. Gray	Male fern; rocky woods	Rhizome & stipes	Aspidium	U	Similar to above
Erigeron canadensis L.	Horseweed; waste places	Volatile oil of entire plant	Oleum Erigerontis	U	Oil similar to but less irritant than oil of turpentine. Diuretic, diaphoretic, styptic
Eupatorium perfoliatum L.	Thoroughwort or boneset; low grounds	Leaves & flowering tops	Eupatorium	O	Diaphoretic, febrifuge
Eupatorium purpureum L.	Joe-Pye weed or trumpet weed; low grounds [except Maine where only the variety occurs, *E. purpureum* var. *maculatum* (L.) Darl.]	Leaves & flowering tops	Swamproot	U	Astringent
Gaultheria procumbens L.	Teaberry or checkerberry or wintergreen; cool woods	Leaves	Gaultheria[c]	U	Aromatic, astringent
Geranium maculatum L.	Wild geranium or wild cranesbill; open woods and fields	Rhizome	Geranium	U	Astringent

[c] Also Synthetic oil of Gaultheria is Official under title of Methylis Salicylas and used as rubefacient, antirheumatic and flavoring agent.

Botanical Origin	*Common Name and Habitat in Northeastern United States*	*Part Used*	*Drug Name*	*Drug Status*	*Medicinal Use*
Hedeoma pulegioides L. Pers.	Amer. pennyroyal; dry fields	Leaves & flowering tops	Hedeoma or Pennyroyal	U	Carminative, aromatic, emmennogogue in colic & stomach disorders. Menstrual flow stimulant
Hydrastis canadensis L.	Golden seal (not in east. N. E.); rich woods	Rhizomes & roots	Hydrastis or Golden Seal[d]	O	Bitter tonic (urinary affections) alterative for mucous membranes
Hypericum perforatum L.	St. John's-wort; fields	Entire plant[e]	Hypericum	U	Vulnerary for bruises
Inula Helenium L.	Elecampane; roadsides and damp pastures	Rhizomes & roots	Inula	U	Diuretic, expectorant, veterinary anticepticin pulmonary diseases
Iris versicolor L.	Blue flag; wet meadows	Rhizome	Iris versicolor or Blue Flag	O	Cathartic, diuretic
Lobelia inflata L.	Indian tobacco; dry open fields and pastures	Leaves and tops	Lobelia	O	Nauseant, antispasmodic smoked with other drugs to relieve asthma
Lycopodium clavatum L.	Common club moss; dry woods	Spores	Lycopodium	O	Water repellent and protective dusting powder
Matricaria Chamomilla L.	Wild or German chamomile; roadsides and waste places (Not in Vt. & N. H.)	Flower head	Matricaria	O	Bitter tonic, carminative
Malva neglecta Wallr. (*M. rotundifolia* L.)	Common mallow or cheeses; waste places and cultivated grounds	Leaves flowers	Malvae Folia Malvae Flores	U U	Demulcent (fruit nutrient), emollient

[d] Also called Hydrastidis rhizoma P.I.

[e] Said to be injurious to browsing cattle due to the photosensitizing principle, hypericin.

Botanical Origin	*Common Name and Habitat in Northeastern United States*	*Part Used*	*Drug Name*	*Drug Status*	*Medicinal Use*
Mentha piperita **L.**	Peppermint; moist places	Leaves & tops	Mentha piperita or Peppermint[f]	O	Carminative, flavoring agent, decreases HCl secretion (relief in peptic ulcer)
Mentha spicata **L.**	Spearmint; moist places	Leaves & tops.	Mentha viridis or Spearmint	O	Carminative flavoring agent
		Volatile oil from fresh aerial parts of flowering plant	Oleum Menthae Piperitae	O	The same
Menyanthes trifoliata **L.**	Buckbean or bog-bean; Sphagnum bogs and shallow water	Leaves	Menyanthes	U	Simple Bitter
Mitchella repens **L.**	Partridge berry or squaw vine; cool, dry woods	Entire plant	Mitchella	O	Diuretic, astringent, menstrual disorders
Nepeta cataria **L.**	Catnip; dry pastures	Leaves and flowering tops	Cataria or Catnip	O	Carminative, or combined with Fennel as a pacifier for infants
Panax quinquefolium **L.**	Ginseng; rich cool woods	Root	Ginseng	U	Aromatic bitter
Podophyllum peltatum **L.**	May apple or mandrake; rich woods (west. N.E. and southward)	Rhizome & roots	Podophyllum or May apple	O	Drastic or hydragogue cathartic
Polygala senega **L.**	Seneca snakeroot; rocky soil in northern part of N.E.	Root	Senega	O	Nauseant expectorant
Rosa canina **L.**	Dog rose; casual escape in Mass., R. I., Conn., N. Y., N. J., of area studied	Spurious fruit	Rosa Canina	U	Refrigerant, Astringent

[f] Menthol derived from Oil of Peppermint is Official. Somewhat antiseptic and used locally with rubefacient, analgesic, cooling & antipyretic effects.

Botanical Origin	*Common Name and Habitat in Northeastern United States*	*Part Used*	*Drug Name*	*Drug Status*	*Medicinal Use*
Rubus allegheniensis **Porter**	Blackberry; dry open thickets and recent clearings	Bark of rhizome & roots	Rubus	U	Astringent in diarrhoeal conditions
Rubus canadensis **L.**	Blackberry; moist, rocky thickets of mts. and hills	Bark of rhizome & roots	Rubus	U	Astringent in diarrhoea
Rubus idaeus **L.**	Red raspberry; thickets	Fresh ripe fruit, expressed juice	Rubus idaeus, liquid known as Succus Rubi Idaei	O	Flavoring agent for refrigerant drinks & medicinal preparations
Rubus occidentalis **L.**	Black raspberry or thimbleberry; fence rows & rich shady slopes	Bark of rhizome & roots	Rubus	U	Astringent in diarrhoea, antispasmodic (uterus)
Rubus strigosus **Michx. (*R. idaeus* L. Var. *aculeatissimus* C. A. Mey. Regel & Tiling.)**	Wild red raspberry; thickets & hills	Fresh ripe fruit, expressed juice	Rubus idaeus, liquid known as Succus Rubi Idaei	O	Flavoring agent for refrigerant drinks & medicinal preparations
Rumex crispus **L.**	Yellow dock; fields, waste, & cultivated places	Root	Rumex	U	Purgative with secondary astringent action
Rumex obtusifolius **L.**	Bitter dock; fields & roadside ditches	Root	Rumex	U	Similar to above. Both sometimes used in diarrhoea
Sanguinaria canadensis **L.**	Bloodroot; open, rich woods	Rhizome	Sanguinaria	O	Nauseant expectorant due to local irritant properties
Senecio aureus **L.**	Golden ragwort or life root; wet meadows & swamps	Entire plant	Senecio	U	In large doses a stimulant followed by depressant action on spinal cord & medulla
Solanum Dulcamara **L.**	Bittersweet; moist banks	Twigs & stems	Dulcamara	U	Sedative, anodyne, narcotic, alterative & resolvent in skin conditions
Symplocarpus foetidus **(L.) Nutt.**	Skunk cabbage; bogs & moist ground	Rhizome & roots	Skunk Cabbage	U	Antispasmodic, emetic (bronchial affections) salve for ringworm & rheumatism

Botanical Origin	*Common Name and Habitat in Northeastern United States*	*Part Used*	*Drug Name*	*Drug Status*	*Medicinal Use*
Taraxacum officinale Weber	Dandelion; pastures & fields	Rhizome & roots	Taraxacum	O	Simple bitter tonic; large doses laxative
Trifolium pratense L.	Red clover; fields & meadows	Inflorescence	Trifolium	O	Alterative, sedative in whooping cough
Trillium erectum L.	Wake robin or trillium; rich woods	Rhizome & roots	Trillium	O	Antispasmodic (uterus), emetic, alterative, astringent
Tussilago Farfara L.	Coltsfoot; moist clay banks & along mt. streams	Leaves	Farfara	U	Demulcent, alterative (coughs & colds)
Thymus Serpyllum L.	Creeping or wild thyme; old fields	Leaves & flowering tops	Serpyllum or Wild Thyme	U	Antispasmodic in whooping cough, asthma, & other respiratory conditions
Valeriana officinalis L.	Garden heliotrope; roadsides & thickets, escaped from cultivation	Rhizome & roots	Valeriana	O	Supposed antihysteric in nervousness, perhaps only a malodorous carminative
Veratrum viride Ait.	Amer. white hellebore; wet meadows & swamps	Rhizome & roots	Veratrum Viride	O	Vasomotor depressant to retard excessive cardiac action
Verbascum Thapsus L.	Common mullein: fields, rocky or gravelly banks	Leaves	Verbasci Folia	U	Demulcent, emollient
Verbascum phlomoides L.	Similar but only in local limited areas	Corolla with stamens	Verbasci Flores	U	Demulcent tea in combination with other ingredients rich in mucilage
Verbena hastata L.	Blue vervain; damp ground & roadsides at lower altitudes	Overground portion	Verbena	U	Expectorant & diaphoretic in form of a hot tea

parison with published historical data (Sievers 1940), the propagation acreage of drug plants in the northeastern United States has decreased decidedly since world war I. For example, in 1918 four growers in New Jersey raised belladonna on approximately 35 acres, whereas the acreage devoted to this species in 1941 was practically nil. Owing to current labor conditions, less than 25 per cent of the nurseries expressed their willingness to grow drug plants even with federal aid. However, in the spring of 1942, the United States Department of Agriculture distributed seed, and in the fall of 1942 between 400 and 500 acres of belladonna were harvested in Wisconsin, Pennsylvania, Virginia, Tennessee, Ohio, and in some states outside the northeastern area.

The wild species of this area involve 51 genera and 67 species. They are all Angiospermae with the exception of 2 genera and 3 species. They have not been utilized effectively in the present emergency. In Maine, no recent cultivation of drug plants has been attempted, but a few individuals have collected with profit such items as juniper berries and lycopodium spores. The natural resources of the other States have not been drawn upon to make any contribution to emergency drug sources. Significant quantities of some of these wild species could be gathered upon request by the medical or pharmaceutical profession for a single season. However, any annual production basis would require cultivated acreages and a concentration of the active principles by selection and breeding.

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STUDIES ON PHILIPPINE CHLOROPHYCEAE—II. SURVEY OF LITERATURE AND LIST OF RECORDED SPECIES PRIOR TO 1940

WILLIAM J. GILBERT

Although the first list of Philippine marine algae was published a little more than a century ago, the number of papers or books that refer to them since that time is surprisingly small. Probably the first record of a marine alga from this region is to be found in the first edition of Blanco's *Flora de Filipinas*, published in 1837. In this work Blanco described nine plants, apparently all from the island of Luzon, to which he gave names that were applicable to alga-like plants. Most of the binomials were preëxisting, but there was no citation of authorities. The descriptions that accompany the names are very general, so that for the most part they cannot be used for determining anything more than the genus to which the plants are to be referred. The difficulties of knowing the particular species with which Blanco was dealing are further increased because there is no permanent record known of the plants he studied.

Among the Thallophyta in Blanco's first edition of *Flora de Filipinas* are to be found the following: *Fucus prolifer* Blanco, *F. denticulatis* Blanco, *F. gulaman* Blanco, *Ulva umbilicalis* Blanco, *U. compressa* Blanco, *U. reticulata* Blanco, *U. intestinalis* Blanco, *Conferva littoralis* Blanco, and *C. setosa* Blanco.

The description of *Fucus prolifer* Blanco unmistakably refers to a species of *Halimeda*, but because of its incompleteness could be applied to one of at least three different species that are relatively common in the Philippines, namely *Halimeda macroloba* Decaisne, *H. Tuna* (Ellis & Solander) Lamouroux f. *platydisca* (Decaisne) Barton, or *H. discoidea* Decaisne. It is interesting to point out that all three of these were described subsequently to Blanco's original work. The plant distributed by Merrill as *Species Blancoanae No. 993*, which he thought duplicated *Fucus prolifer* Blanco, is *Halimeda macroloba* Decaisne.

The second name in the list above, *Fucus denticulatus*, is apparently a *Sargassum;* in the second edition (1845) of the *Flora de Filipinas F. denticulatus* is replaced by the name *F. natans* Blanco. *F. gulaman*, called *F. edulis* in the second edition, may be a *Gracilaria*. The plant listed as *Ulva umbilicalis* seems to be a species of *Padina*. The *Ulva compressa* of Blanco appears undoubtedly to be a species of *Enteromorpha*, and his *Ulva reticulata* does not appear to be *U. reticulata* Forsskål, but it is more likely a species of *Hydroclathrus*, for in the description he speaks of its brown color. Blanco's *Ulva intestinalis* does seem to correspond with *U. intestinalis* Linnaeus, now known as *Enteromorpha intestinalis* (L.) Link. The last names in the list above are not marine plants, for the description of *Conferva littoralis* refers to a species of *Chara*, and *Conferva setosa* Blanco is probably not an alga, for it is reported growing from the leaves of trees and looking like the hairs of a horse. The latter may have been a species of the algal genus *Trentepohlia* or a representative of the lichen family Usneaceae.

From this list it is possible, therefore, to claim only three of the nine species as marine Chlorophyceae, being fairly certain of the identity of *Enteromorpha intestinalis* (L.) Link, and knowing only the genera of the other two with certainty (*Enteromorpha* sp. and *Halimeda* sp.).

Five years later Berkeley (1842) in his "Enumeration of fungi collected by H. Cuming in the Philippine Islands," described as a fungus under the name *Dichonema erectum* a plant that A. Gepp and E. S. Gepp later showed to be an alga, and which they named *Avrainvillea erecta* (Berkeley) A. & E. S. Gepp.

Following this by two years, a paper by Montagne (1844) dealing with the plants collected by H. Cuming in the Philippines, listed the following seven species of green algae: *Cladophora pellucida* (Hudson) Kützing, *Ulva reticulata* Forsskål, *Caulerpa taxifolia* (Vahl) C. Agardh, *C. plumaris* (Forsskål) C. Agardh, *Codium tomentosum* (Hudson) Stackhouse, *Udotea sordida* Montagne, and *Halimeda discoidea* Decaisne. In this list *Cladophora pellucida*, *Ulva reticulata*, *Caulerpa taxifolia*, and *Halimeda discoidea* are still accepted species. Of the others, *Caulerpa plumaris* is synonymous with *C. sertularioides* (Gmelin) Howe, *Codium tomentosum* is synonymous with *C. dichotomum* (Hudson) S. F. Gray, and *Udotea sordida* (described by Montagne as new in his paper) is *Avrainvillea erecta* (Berkeley) A. & E. S. Gepp.

The Chlorophyceae from the Philippines are next mentioned by G. von Martens (1866), reporting on the botany of the Prussian Expedition to East Asia, who listed the following nine species from the region of Zamboanga, Mindanao: *Chaetomorpha inflata* Kützing, *Ulva reticulata* Forsskål, *Chauvinia clavifera* Turner, *Halimeda Opuntia* (L.) Lamouroux, *H. discoidea* Decaisne, *H. cuneata* Kützing, *Valonia utricularis* Roth, *V. macrophysa* Kützing, and *Microdictyon clathratum* Martens.

Regarding the first of the preceding list, this is one of the very few reports of *Chaetomorpha inflata* since it was first described by Kützing from Java, and because Martens described it so briefly and the occurrence of the species appears to be so rare, it is to be considered a doubtful record until it can be verified. *Chauvinia clavifera* is now synonymous with *Caulerpa racemosa* (Forsskål) J. Agardh var. *clavifera* (Turner) Weber-van

Bosse. *Halimeda cuneata* Kützing (not *H. cuneata* Hering) is listed by Barton (1901) among the synonyms of *H. gracilis* Harvey. *Valonia macrophysa* is not definitely known from the Pacific or Indian Oceans, and since the report of it was not accompanied by a description the record is to be seriously questioned. *Microdictyon clathratum,* described by Martens as new, is actually *Anadyomene Leclancherii* Decaisne. Interestingly enough, this same year Gray (in his article "On *Anadyomene* and *Microdictyon*, with the description of three new allied genera," etc.) referred a specimen from the Sulu Archipelago that Harvey had sent him to *Cystodictyon Leclancherii* (Decaisne) Gray, having considered that *Anadyomene Leclancherii* Decaisne was sufficiently different from other species of *Anadyomene* to constitute the type of a new genus.

Dickie (1876), in his "Contributions to the botany of the expedition of H. M. S. 'Challenger.'—Algae, chiefly Polynesian," adds considerably to the list of Philippine marine Chlorophyceae. He lists about 47 species of algae from the Philippines and among them are the following Chlorophyceae: From the island of Mactan, opposite the Harbor of Cebu, *Halimeda Opuntia* (L.) Lamouroux, *H. macroloba* Decaisne, *Codium tomentosum* (Hudson) Stackhouse, *C. adhaerens* (Cabrera) C. Agardh, *Polyphysa spicata* Kützing, *Ulva reticulata* Forsskal; from Zamboanga, Mindanao, *Caulerpa peltata* Lamouroux, *C. clavifera* (Turner) C. Agardh, *Halimeda Tuna* Lamouroux, *Valonia utricularis* Roth, *Dictyosphaeria favulosa* (C. Agardh) Decaisne, *Ulva reticulata* Forsskål, *Cladophora mauritiana* Kützing; from Big Santa Cruz Island, opposite Zamboanga, *Caulerpa plumaris* (Forsskål) C. Agardh, *Halimeda Opuntia* (L.) Lamouroux, *Valonia fastigiata* Harvey, and *Anadyomene flabellata* Lamouroux.

The determination of the material which Dickie called *Polyphysa spicata* is incorrect, and the specimens should have been named *Halicoryne Wrightii* Harvey according to Solms-Laubach (1895) who saw the material while preparing his "Monograph of the Acetabularieae." *Caulerpa clavifera* is synonymous with *C. racemosa* var. *clavifera*, and *Dictyosphaeria favulosa* is now known as *D. cavernosa* (Forsskal) Børgesen. *Cladophora mauritiana* is known only from the Indian Ocean, except for this report from the Philippines, and the determination is therefore questionable, especially since it is not accompanied by a description. *Anadyomene flabellata* is now known as *A. stellata* (Wulfen) C. Agardh, but the writer is inclined to feel that the material here reported is more likely either *Anadyomene Wrightii* Harvey or *A. plicata* C. Agardh, both of which are common species of this region.

Just a year later Dickie (1877) published an additional paper which was entitled "Supplementary notes on algae collected by H. N. Moseley of H. M. S. 'Challenger' from various localities." In this paper he listed a few additional species from the Philippines, and among them (from Zamboanga) is included a single marine chlorophyceean, *Acetabularia Calyculus* Quoy & Gaimard.

Piccone (1886) in his *Alghe del viaggio di circumnavigazione della Vettor Pisani* listed the following Chlorophyceae from the island of Ticao, Masbate Province: *Ulva reticulata* Forsskål, *Enteromorpha flexuosa* J. Agardh, *Caulerpa laetevirens* Montagne, and *Codium tomentosum* (Hudson) Stackhouse. Of these four species *Enteromorpha flexuosa* had not been previously reported. *Caulerpa laetevirens* is synonymous with *C. racemosa* (Forsskål) J. Agardh var. *laetevirens* (Montagne) Weber-van Bosse.

From the results of the Siboga Expedition are added several more species to the list of marine Chlorophyceae from the Philippines. Barton (1901) in her monograph on "The genus *Halimeda*" reported that *Halimeda Opuntia* (L.) Lamouroux and *H. macroloba* Decaisne are found among the Siboga collections from the Sulu Archipelago. Ten years later A. Gepp and E. S. Gepp (1911) add the following seven species in the report of "The Codiaceae of the Siboga Expedition," these also being from the region of the Sulu Archipelago: *Udotea orientalis* A. & E. S. Gepp, *U. argentea* Zanardini var. *spumosa* A. & E. S. Gepp, *U. Flabellum* (Ellis & Solander) Lamouroux, *Codium difforme* Kützing, *C. ovale* Zanardini, *C. tenue* Kützing, and *C. elongatum* C. Agardh.

Mme. Weber-van Bosse (1913) in the "Liste des algues du Siboga, I" reported the following Chlorophyceae as occurring among the collections from the Sulu Archipelago in addition to the species from the Siboga Expedition mentioned in the two preceding articles: *Ulva Lactuca* L., *U. reticulata* Forsskål, *Enteromorpha crinita* (Roth) C. Agardh, *Cladophoropsis sundanensis* Reinbold, *Valonia utricularis* C. Agardh, *V. fastigiata* Harvey, *Bornetella sphaerica* Zanardini, *B. oligospora* Solms-Laubach, *Caulerpa sertularioides* (Gmelin) Howe, *C. Selago* (Turner) C. Agardh, *C. Freycinettii* (C. Agardh) Weber-van Bosse, and *C. crassifolia* (C. Agardh) J. Agardh. In the list above *C. Freycinettii* has become *C. serrulata* (Forsskål) J. Agardh *emend.* Børgesen.

In 1918 Merrill published his "Species Blancoanae," a critical revision of the Philippine species of plants described by Blanco and Llanos, and in it three species are referred to the Chlorophyceae, namely *Enteromorpha intestinalis* (L.) Link, *E. prolifera* J. Agardh, and *Halimeda Opuntia* (L.) Lamouroux. There is no reason to doubt the accuracy of the first two determinations, but the plant which Merrill distributed in the exsiccata as *Species Blancoanae No. 993* is not *Halimeda Opuntia*, but rather *H. macroloba* Decaisne.

According to the late Dr. M. A. Howe (1932), there are the following Chlorophyceae among the algae collected at Panay Island by Lieut. H. C.

Kellers, M.D., who was attached as surgeon to the Naval Eclipse Expeditions of 1929 and 1930: *Enteromorpha lingulata* J. Agardh, *Chaetomorpha Kellersii* Howe, *Caulerpa clavifera* (Turner) C. Agardh, *C. macrodisca* Decaisne, and *Acetabularia major* Martens. The plant which Howe called *Caulerpa macrodisca* is *C. peltata* Lamouroux var. *macrodisca* (Decaisne) Weber-van Bosse.

SUMMARY OF RECORDS

Following is a check-list of all Philippine marine Chlorophyceae appearing in the literature before 1940; it has been arranged systematically so that the species come under the order and family to which they belong; each species is followed by the name of the author or authors reporting it, and the name under which it was listed if that name differs from the present accepted name. When the accuracy of a determination is in doubt the specific name is preceded by a question mark; species for which the Philippines is the type locality are marked by an asterisk.

ULOTRICHALES

ULVACEAE

ENTEROMORPHA CRINITA (Roth) C. Agardh. (Weber-van Bosse, 1913.)
E. FLEXUOSA (Wulfen) J. Agardh. (Piccone, 1886.)
E. INTESTINALIS (L.) Link. (Blanco, 1837, as *Ulva intestinalis;* Merrill, 1918.)
E. LINGULATA J. Agardh. (Howe, 1932.)
E. PROLIFERA J. Agardh. (Merrill, 1918.)
ULVA LACTUCA L. (Weber-van Bosse, 1913.)
U. RETICULATA Forsskål. (Montagne, 1844; Martens, 1866; Dickie, 1876; Piccone, 1886; Weber van Bosse, 1913.)

SIPHONOCLADALES

VALONIACEAE

DICTYOSPHAERIA CAVERNOSA (Forsskål) Børgesen. (Dickie, 1876, as *D. favulosa.*)
VALONIA FASTIGIATA Harvey. (Dickie, 1876; Weber-van Bosse, 1913.)
? V. MACROPHYSA Kützing. (Martens, 1866.)
V. UTRICULARIS Roth. (Martens, 1866; Dickie, 1876; Weber-van Bosse, 1913.)

BOODLEACEAE

CLADOPHOROPSIS SUNDANENSIS Reinbold. (Weber-van Bosse, 1913.)

ANADYOMENACEAE

ANADYOMENE LECLANCHERII Decaisne. (Martens, 1866, as *Microdictyon clathratum;* Gray, 1866, as *Cystodictyon Leclancherii.*)
? A. STELLATA (Wulfen) C. Agardh. (Dickie, 1876, as *A. flabellata.*)

CLADOPHORACEAE

? CLADOPHORA MAURITIANA Kützing. (Dickie, 1876.)
C. PELLUCIDA (Hudson) Kützing. (Montagne, 1844.)
? CHAETOMORPHA INFLATA Kützing. (Martens, 1866.)
* C. KELLERSII Howe. (Howe, 1932.)

DASYCLADALES

DASYCLADACEAE

BORNETELLA SPHAERICA (Zanardini) Solms-Laubach. (Weber-van Bosse, 1913.)

B. OLIGOSPORA Solms-Laubach. (Weber-van Bosse, 1913.)

HALICORYNE WRIGHTII Harvey. (Dickie, 1876, as *Polyphysa spicata.*)

ACETABULARIA CALYCULUS Quoy & Gaimard. (Dickie, 1877.)

A. MAJOR Martens. (Howe, 1932.)

SIPHONALES

CAULERPACEAE

CAULERPA CRASSIFOLIA (C. Agardh) J. Agardh. (Weber-van Bosse, 1913.)

C. PELTATA Lamouroux, (Dickie, 1876; Howe, 1932, as *C. macrodisca.*)

C. RACEMOSA (Forsskål) J. Agardh

var. *clavifera* (Turner) Weber-van Bosse. Martens, 1866, as *Chauvinia clavifera;* Dickie, 1876, as *Caulerpa clavifera;* Howe, 1932, as *C. clavifera.*)

var. *laetevirens* (Montagne) Weber-van Bosse. (Piccone, 1886, as *C. laetevirens.*)

C. SELAGO (Turner) C. Agardh. (Weber-van Bosse, 1913.)

C. SERRULATA (Forsskål) J. Agardh *emend.* Børgesen. (Weber-van Bosse, 1913, as *C. Freycinettii.*)

C. SERTULARIOIDES (Gmelin) Howe. (Montagne, 1842, as *C. plumaris;* Dickie, 1876, as *C. plumaris;* Weber-van Bosse, 1913.)

C. TAXIFOLIA (Vahl) C. Agardh. (Montagne, 1844.)

CODIACEAE

* AVRAINVILLEA ERECTA (Berkeley) A. & E. S. Gepp. (Berkeley, 1842, as *Dichonema erectum;* Montagne, 1844, as *Udotea sordida;* A. & E. S. Gepp, 1911.)

UDOTEA ARGENTEA Zanardini var. *spumosa* A. & E. S. Gepp. (A. & E. S. Gepp, 1911; Weber-van Bosse, 1913.)

U. FLABELLUM (Ellis & Solander) Lamouroux. (A. & E. S. Gepp, 1911; Weber-van Bosse, 1913.)

U. ORIENTALIS A. & E. S. Gepp. (A. & E. S. Gepp, 1911; Weber-van Bosse, 1913.)

CODIUM ADHAERENS (Cabrera) C. Agardh. (Dickie, 1876.)

? C. DICHOTOMUM (Hudson) S. F. Gray. (Montagne, 1844, as *C. tomentosum;* Dickie, 1876, as *C. tomentosum;* Piccone, 1886, as *C. tomentosum.*)

C. DIFFORME Kützing. (A. & E. S. Gepp, 1911; Weber-van Bosse, 1913.)

C. ELONGATUM C. Agardh. (A. & E. S. Gepp, 1911; Weber-van Bosse, 1913.)

C. OVALE Zanardini. (A. & E. S. Gepp, 1911; Weber-van Bosse, 1913.)

C. TENUE Kützing. (A. & E. S. Gepp, 1911; Weber-van Bosse, 1913.)

HALIMEDA DISCOIDEA Decaisne. (Montagne, 1844; Martens, 1866.)

H. GRACILIS Harvey. (Martens, 1866, as *H. cuneata* Kützing.)

H. MACROLOBA Decaisne. (Dickie, 1876; Barton, 1901; Weber-van Bosse, 1913; Merrill, 1918, as *H. Opuntia.*)

H. OPUNTIA (L.) Lamouroux. (Martens, 1866; Dickie, 1876; Barton, 1901; Weber-van Bosse, 1913.)

H. TUNA Lamouroux. (Dickie, 1876.)

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A REVIEW OF THE STATUS OF SEVERAL AMERICAN SPECIES OF DALEA

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This article is the result of a study to determine the proper scientific name for the species of *Dalea* which is native in southern Florida. At first thought, this might seem like an easy task. One should need only to consult Small's *Manual of the Southeastern Flora,* which covers all of Florida. There the name is given as *Parosela floridana* Rydberg. This binomial was proposed in 1920 for a segregate from what had previously been called *Parosela domingensis* (DC.) Millsp. (*Dalea domingensis* DC.). In his key, Rydberg (N. Am. Flora **24**: 72. 1920) used for distinguishing characteristics for *P. floridana* the shorter and denser inflorescence, the slightly winged leaf-rachis, the scarcely hooked calyx-lobes and the 9–17 leaflets of each leaf. *P. domingensis* of the West Indies, on the other hand, was said to have an inflorescence which, at least in fruit, is lax. Also the calyx-lobes were described as decidedly hooked at the apex, the leaf-rachis decidedly winged and the leaflets 5–9. On a basis of these several correlated differences, *Parosela floridana* would appear to be an amply distinct species. Since *Dalea* is a conserved name and the necessary combination for the species in that genus is lacking, one might feel justified in making the transfer, but a study of actual specimens and a review of the nomenclatural history of related species introduces complications.

First, a series of specimens from Florida exhibits a greater amount of variability in that population than Rydberg's description suggests. The inflorescence, for example, varies from very short to relatively long. The rachises of the leaves are usually winged, even if not decidedly so. On every specimen examined, at least some of the lobes of the calyx are hooked. Finally, the number of leaflets varies from as few as seven to twenty-one per leaf. All this indicates that the inexperienced student may encounter trouble in separating *P. floridana* from *P. domingensis* on a basis of morphological characteristics. The differences cited by Rydberg are too definitely stated. Actually they seem to indicate evolutionary tendencies, not completely evolved species. As a result of study of the plants of Florida alone, considerable doubt arises concerning the validity of *P. floridana* as a separate species.

Parosela domingensis, as circumscribed by Rydberg in 1920, occurs in the West Indies and northern South America. Study of a series of specimens in the herbarium of the New York Botanical Garden likewise reveals

TABLE 1. *Data showing variability of certain characteristics in populations of Dalea*

Locality	Cuba	Hispaniola	Puerto Rico	Northern South America	Peninsula of Florida
Number of specimens examined	7	2	3	4	14
Inflorescence					
lax (no. of specimens)	4	2	0	0	0
dense (no. of specimens)	3	0	3	4	14
length in cm.	0.6–4.5 (av. 1.5)	0.8–1.8 (av. 1.3)	0.6–2.5 (av. 1.5)	0.7–1.6 (av. 1.1)	0.4–2.5 (av. 1.2)
Lobes of calyx					
hooked (no. of specimens)	7	2	2	0	14
not hooked (no. of specimens)	0	0	1	4	0
length in mm.	2–4 (av. 2.6)	4–6 (av. 4.7)	2–5 (av. 3)	3–4 (av. 3.5)	1–5 (av. 3)
Leaflets (no. per leaf)	3–11 (av. 6.7)	5–15 (av. 11)	7–15 (av. 11)	7–17 (av. 12)	7–21 (av. 14)
Rachis of leaf					
winged	7	2	3	4	14
not winged	0	0	0	0	0

a degree of variability far surpassing what might be expected from Rydberg's treatment. In table 1, data are presented for several supposedly important characteristics. These are summarized for three islands in the West Indies and northern South America. For purposes of comparison, data are also included for specimens from Florida.

Study of table 1 reveals that the populations of *Parosela domingensis* vary from island to island as well as from the mainland, also that there is no decisive set of major characteristics by which the plants of Florida may be separated from those of the islands. Only slight differences distinguish the several geographical populations. Even these differences may not be so great as indicated because the small numbers of specimens examined probably do not accurately show the range of variability in the several populations. Keeping in mind the shortcomings of the data, a few tendencies may be noted. Plants from Cuba have the longest inflorescences and average the smallest number of leaflets per leaf. The lobes of the calyx are longer in plants from Hispaniola than from elsewhere. Plants from Puerto Rico resemble those from Cuba in the length of the inflorescences, but differ in having more leaflets per leaf, as do those from Hispaniola. The plants from Florida and northern South America are similar in having the largest number of leaflets per leaf, but the lobes of the calyx are at least partially hooked in plants from Florida, but are not hooked in plants from South America. Specimens from the West Indies or the American mainland can be assigned with certainty to proper geographical population only after careful study. The extremes of variation shown in table 1 are great, while the differences are relatively slight. For that reason, the writer does not regard these geographical populations as worthy of designation as species, though the tendencies in divergence are perhaps strong enough to warrant their designation as subspecies.

The relationships of *Parosela floridana* are further complicated by the occurrence in the lower Rio Grande valley and from there southward in Mexico of a population which has in recent times been called *P. humilis* or *P. thyrsiflora*. Standley, in "Trees and Shrubs of Mexico" (Contr. U. S. Nat. Herb. **23**(2): 455. 1922) separated *P. humilis* from *P. domingensis* as follows:

Spikes, at least in fruit, lax; leaf rachis evidently winged.	*P. domingensis.*
Spikes short and dense; rachis scarcely winged.	*P. humilis.*

Small, in his *Flora of the Southeastern United States* (p. 626. 1913), separated these so-called species as follows:

Leaflets 9–13.	*Parosela domingensis.*
Leaflets 5–9.	*Parosela thyrsiflora.*

Study of a series of eight specimens from the Gulf slope of Texas and Mexico reveals the variation in this population. In number of leaflets per leaf, these specimens exactly support Small's statement of 5–9, but already we have found a similar situation in the Cuban population with the leaflets 3–11. The inflorescences vary in length from 5 to 20 mm. Compared with specimens from elsewhere, these are not remarkably short and dense. Inflorescences of plants from northern South America and Hispaniola are shorter, and those from Puerto Rico and Florida are equally short. Thus *P. thyrsiflora* is like *P. domingensis* from Cuba in number of leaflets, but most like Puerto Rican *P. domingensis* or Floridan *P. floridana* in length of inflorescence. It is not drastically different from these other populations. For that reason, *P. thyrsiflora* seems scarcely tenable as a separate species, but perhaps sufficiently distinctive to be considered a geographical subspecies. Although Small stated the range of both *P. domingensis* and *P. thyrsiflora* to include Texas, no Texan specimens of so-called *P. domingensis* have come to the writer's attention to support this statement.

If we search through the sheets of *Dalea* (*Parosela*) in a large herbarium, we will find specimens appearing similar to *P. domingensis*, *P. floridana*, and *P. thyrsiflora* from Florida, the West Indies, the lower Rio Grande Valley in Texas, the Gulf slope of Mexico, Central America, and northern South America. This composite population has received many names, but before discussing nomenclature, we must consider several other related species. Two of these are *Psoralea scandens* and *Dalea humilis*. Miller proposed the former name in 1768 for an American plant with climbing stem and blue flowers. At the New York Botanical Garden is a photograph of what is probably the type of this species. It is attached to a sheet bearing a specimen collected by C. A. Purpus, no. 2346, at Zacuapan, State of Vera Cruz, Mexico. The plant of Purpus and *Psoralea scandens* do not appear to be the same. *P. scandens* appears more lax and vine-like, with broader, larger leaflets, also the flowers are described as blue. The specimen from Zacuapan is a small shrub. It is not vine-like and has smaller, narrower leaflets. The petals appear to be yellowish. The distributional area of *P. scandens* is unknown to the writer, neither have any specimens come to his attention. Yet, on the basis of the photograph just mentioned and the original description, this seems to be a sufficiently distinct species. It should now be called **Dalea scandens** (Miller) Clausen, comb. nov., based on *Psoradea scandens* Miller, Gardeners' Dictionary, ed. 8, *Psoralea* no. 4 (1768). The other species to be considered at this point is *Dalea humilis* G. Don. Gen. Hist. **2**: 224 (1832). This was described originally from Mexico. It is an annual with slender stems and narrow leaflets which are acute at either end. In 1847, Schauer proposed the binomial *D. inconspicua* for this species, but that name should now be assigned to synonymy under *D. humilis* G. Don. This species occurs on the Pacific slope of Mexico where it ranges from Guadalajara and Chapala to Monte Alban near Oaxaca. The altitudinal range is from 1524 to 2438 m.

Other names which perhaps should also be considered in this discussion are *Dalea microphylla* H.B.K. and *D. trichocalyx* Ulbrich. These species are both South American and poorly understood by the writer. Their relationships to the species under discussion is not clear, but probably their status will not affect the nomenclatural conclusions set forth below. Likewise, the relationships of *Dalea vulneraria* Oerst. and *Parosela occidentalis* require elucidation.

The population primarily under discussion here, the one to which *Parosela domingensis*, *P. floridana*, and *P. thyrsiflora* belong, includes perennials with stout stems and leaflets which are broadly oblong-elliptical and rounded or retuse at the apex. Miller, in 1768, was probably the first to apply a name to any part of this population, namely *Psoralea humilis*. In 1790, Jacquin independently proposed a name for this same species, *Psoralea emphysodes*, typified by a plant from Caracas in South America. This was said to flower in December and January and to have hairy stems and purplish or white petals. In 1793, Jacquin published a colored plate of this species, but he changed the name to *Psoralea phymatodes*. The plate shows the leaflets and stems as glandular, but not hairy. Except for the absence of pubescence, and the straight lobes of the calyx, the plant in Jacquin's illustration resembles plants from Florida and demonstrates that the plants from there and from South America belong to the same species. Macbride in 1927 (Field Mus. Pub. Bot. **4**: 102) expressed similar views regarding the relationships of *P. emphysodes*. Since Miller's epithet, *humilis*, is not available in *Dalea* because of *D. humilis* Don., Jacquins' name, *emphysodes*, should now be applied to the aggregate species, which should be designated as **Dalea emphysodes** (Jacquin) R. T. Clausen, comb. nov., based on *Psoralea emphysodes* Jacquin, Coll. **4**: 144 (1790). This is separated from related species in the following key:

A. Stems climbing, to 2 m.; flowers blue. *D. scandens.*
AA. Stems not climbing, to 1.8 m.; flowers white, pink or yellowish, becoming brownish purple. B.
  B. Plants annual; stems slender, 0.5–2 mm. in diam. at base; leaflets narrowly linear or oblong-elliptical, acute at either end. *D. humilis.*
  BB. Plants perennial; stems stout, 2–5 mm. in diam. at base; leaflets broadly oblong-elliptical, rounded or retuse at apex. *D. emphysodes.*

The polytypic species, *D. emphysodes*, may now be characterized as follows: Villous or glabrous, glandular-punctate perennials with stout stems to 15 dm. tall, 2–5 mm. in diam. at base; leaves alternate, pinnately compound with rachises which are more or less winged and 3–21 leaflets which are broadly oblong-elliptical, rounded or retuse at apex, 2–15 mm. long, 1–6 mm. broad; flowers in axillary and terminal racemes, 0.4–4.5 cm. long; calyces 4–8 mm. long, with lobes linear, acute, 1–6 mm. long, hooked, recurved or straight; petals 5–10 mm. long, white, pink or purplish, becoming brownish purple; stamens diadelphous, 5–7 mm. long; pistils densely villous.

Flowering time is September to May. The distributional area includes southern Florida, the lower Rio Grande Valley, the Gulf slope of Mexico and Central America, the Pacific slope of Central America in El Salvador, the Caribbean slope of northern South America, and the islands of Cuba, Hispaniola, and Puerto Rico.

Three geographical subspecies seem sufficiently isolated and differentiated to warrant recognition. These are named and characterized, after which a key is provided for their separation.

D. EMPHYSODES subsp. **emphysodes** (Jacquin) R. T. Clausen, subsp. nov. Based on *Psoralea emphysodes* Jacquin, *ibid.*, described originally from Caracas and characterized by leaves with 7–17 leaflets, averaging 12 leaflets per leaf, and short lobes of the calyx, 3–4 mm. long, which are not hooked. This subspecies occurs on the Caribbean slope of northern South America in Colombia and Venezuela at altitudes from 46–440 m., also in Puerto Rico. Synonyms are *Psoralea phymatodes* Jacquin, Ic. Plant. Rar. **3**: 1338 (1803); and *Parosela emphysodes* (Jacq.) Rydb. N. Am. Flora **24** (2): 113 (1920).

D. EMPHYSODES subsp. **domingensis** (DC.) R. T. Clausen, comb. nov. Based on *Dalea domingensis* DC. Prodr. **2**: 246 (1825) and characterized by the leaves with 5–15 leaflets, averaging 11 leaflets per leaf, and the lobes of the calyx which are 1–6 mm. long, averaging 3.5 mm. and all or partially hooked. This subspecies is known only from Hispaniola, which is the type locality, Puerto Rico, and northern Florida, where it occurs north to latitude 26° 45′ N at Palm Beach. Synonyms are *D. enneaphylla* Bert. in DC. *ibid.* (as a synonym); *Parosela domingensis* (DC.) Millsp. Field Mus. Pub. Bot. **1**: 21 (1895): and *Parosela floridana* Rydb. N. Am. Flora **24**: 114 (1920).

D. EMPHYSODES subsp. **thyrsiflora** (A. Gray) R. T. Clausen, comb. nov. Based on *Dalea thyrsiflora* A. Gray, Proc. Am. Acad. **5**: 177 (1861) and characterized by leaves with 3–11 leaflets. Subsp. *thyrsiflora* occurs in the lower Rio Grande Valley and from there southward, mostly at low altitudes along the Gulf slope of Mexico and Central America, also it occurs on the Pacific slope of Central America in El Salvador, and in Cuba. Synonyms are *Dalea domingensis* var. *paucifolia* Coult. Contr. U. S. Nat. Herb. **1**: 34 (1890); *Parosela thyrsiflora* Vail, Bull. Torrey Club **24**: 14 (1897); and *Parosela humilis* Rydberg, N. Am. Flora **24**(2): 114 (1920). Without inspection of the type, I am unable to assign to a subspecies *Psoralea humilis* Mill. Gard. Dict. ed. 8, *Psoralea* no. 7 (1768). This is the earliest specific epithet to be applied to *D. emphysodes*, but it cannot be employed under *Dalea* because of *D. humilis* G. Don.

KEY TO THE SUBSPECIES OF DALEA EMPHYSODES

A. Leaflets 5–21, averaging 11 or more. . B.
  B. Lobes of calyx not hooked, plants glabrous or pubescent.
    D. emphysodes subsp. *emphysodes*.
  BB. At least part of lobes of calyx hooked; plants pubescent.
    D. emphysodes subsp. *domingensis*.
AA. Leaflets 3–11, averaging 7 or fewer. *D. emphysodes* subsp. *thyrsiflora*.

DEPARTMENT OF BOTANY, CORNELL UNIVERSITY
ITHACA, NEW YORK

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FICUS TSJAHELA

MARY F. BARRETT

Ficus tsjahela Burm.f. is sufficiently characterized by at least two excellent illustrations and several good descriptions; but has been associated with a disproportionately large number of obvious, but sometimes uncorrected mistakes. It is the purpose of this study to rectify the mistakes, especially that in the title, to comment upon synonymous names, and to distinguish the species from others with which it has been confused.

FICUS TSJAHELA Burm.f. Fl. Ind. 227. 1768. (Spelled *Tsjakela* by Burman.)

Tsjahela Rheede, Hort. Mal. 3: 87. *pl. 64.* 1682. (Originally spelled *Tsjakela*, but corrected on p. 88.)

F. malabarica semel in anno fructifera, fructu minimo, tsjahela dicta Ray, Hist. Pl. 2: 1435. 1688. (Spelled *Tsjakela.*)

F. surattensis Hb. Garcin ex Burm.f. Fl. Ind. 227. 1768.

F. surattensis var. *malabarica, mori folio* Hb. Garcin ex Burm.f. (*above*).

F. venosa Ait. Hort. Kew. 3: 451. 1789. Not Willdenow.

Pella ribesioides Gaertn. Fruct. Sem. Pl. 1: 143. *pl. 28. f. 8.* 1791.

F. tsjahela Rheede ex Vahl, Enum. Pl. 2: 185. 1806. (Spelled *Tsjakela.*)

F. infectoria Willd. Sp. Pl. 4: 1137. 1806. Not Roxburgh.

F. indica Moon, Cat. Pl. Ceylon 74. 1824. Not Linnaeus.

F. sp. Hb. Heyn. ex Wall. Cat. no. 4519 B. 1831.

Urostigma tsjahela (Burm.f.) Miq. Hook. Lond. Jour. Bot. 6: 567. 1847. (Spelled *Tjakela.*)

U. caulobotryum Miq. Hook. Lond. Jour. Bot. 6: 568. 1847.

U. ceylonense Miq. Hook. Lond. Jour. Bot. 6: 570. 1847. (Misprinted *ceylonnese.*)

U. infectorium Thwaites, Enum. Pl. Zeylaniae 265, in part. 1864.

F. caulobotrya (Miq.) Miq. Ann. Mus. Bot. Lugd.-Bat. 3: 287. 1867. Not Vidal.

Tall tree, much branched, without aerial roots, glabrous; petioles to 7.5 cm. long; blades elliptic tending towards oblong, typically 12.5–19 × 5.5–9 cm., but also 5–9 × 3–5 cm. in a smaller form (examples: 18 × 9 cm., 19 × 8.5 cm., 8 × 5 cm.); base broad, rounded or subcordate; apex slightly narrowed, then abruptly acuminate; acumen thick, about 1 cm. long; upper surface glossy in life, iron- or dark greenish-gray when dried; basal veins similar to the lateral veins; 8–10 sets of conspicuous lateral veins, the upper angle 65° to 75°; only discontinuous tertiary veins; a distinct reticulum and a checkered background; mature receptacles 1–6 on tubercles in the defoliated axils, sessile or short-peduncled, depressed-globose, about 5 mm. in cross diameter when dried, yellowish and dotted when ripe; basal bracts 3, large, almost semicircular, sometimes lobed, the edges loose; male flowers said to have 3 ovate acuminate perianth-parts shorter than the stamen; anther ovate, on a filament of equal length; gall and female flowers with 3–4 perianth-parts; achene obovate, the style long, the stigma cylindric.

TYPE: India: Malabar, Surat.

Distribution: India, especially the west coast and the south; Ceylon; Indo-China.

F. tsjahela sometimes has been confused with the type of *F. lacor* Ham. (formerly known as *F. infectoria* Roxb.). As compared with *F. tsjahela*, *F. lacor* may have aerial roots; and its leaves show a seldom cordate base, a longer slender acumen, distinct basal veins, lateral veins leaving the midrib at a more acute angle, and fewer tertiary veins. Its figs usually are larger, white with a pinkish tinge, sessile, and single or paired in leafy axils. Its distribution includes but extends far beyond that of *F. tsjahela*.

F. geniculata Kurz (For. Fl. Brit. Burma **2**: 447. 1877) resembles *F. tsjahela* closely, but is sometimes pubescent on twigs and fig-peduncles. Its leaf-blades are broader in proportion to their length and show more secondary lateral veins leaving the midrib at a greater angle, and some continuous tertiary veins. Its figs are larger and its male flowers gamophyllous. Its distribution is northeastern India, Burma, Indo-China, and Malaya.

NAMES APPLIED TO THE SPECIES

The prototype of *F. tsjahela* is described as *Tsjakela* on the next-to-last page of the third volume of Rheede's *Hortus indicus malabaricus*. On the last page of that volume under both *Index* and *Errata* the spelling of the name is corrected to *Tsjahela*. The excellent *plate 61* which accompanies the text bears the title *Tsiela*, which had been given previously to *plate 63*. That these illustrations represent different plants is apparent from the contrasting pictures and the vernacular names inscribed on each sheet. The mistake in the plate seems to have misled few people; but the incorrect use of *k* in the text has been followed by almost all writers on the subject, some of whom have introduced other variations: *Tsjakala* by J. Burman (Fl. Mal. 9. 1769) and Graham (Cat. Pl. Bombay 191. 1839), *Tsjakele* by Steudel (Nom. Bot. ed. 2. **1**: 638. 1840), and *Tjakela* by Miquel (Hook. Lond. Jour. Bot. **6**: 567. 1847, and later), King (Ann. Bot. Gard. Calcutta $\mathbf{1}^1$: 57–58, *pl. 70, 84*^{B}. 1887; and *in* J. D. Hooker, Fl. Brit. India **5**: 514. 1888), Brandis (Ind. Trees 603. 1906), and others. In this study correct spelling will be used unless it is desired to show the author's orthography.

The pre-Linnean Latin polynomial proposed by Ray as the title of this species was so used by K. Commelin (Fl. Mal. 29. 1696) and was mentioned as a synonym by Stokes (Bot. Mat. Med. **4**: 358. 1812).

N. Burman cited *Tsjahela* Rheede and a species and variety from the herbarium of L. Garcin as synonyms of "*F. tsjakela*." He characterized the leaves as ovate-oblong, entire and crenate, thus including both Rheede's type and Garcin's variety. No record of crenate leaves seems to have been made by other writers, although the term *undulate* sometimes has been used

In 1789 Aiton described *F. venosa*, an exotic from the East Indies, and cited *Tsjahela* Rheede. The specific name recalls Rheede's statement that the leaves have whitish veins. This title became one of the two most frequently used until King (1887) traced the synonymy and established the priority of the name given by Burman. The authorship of *F. venosa* Ait. sometimes was ascribed to others: to Willdenow by Dennstedt (Schlüss. Hort. Mal. 29. 1818), to the text in Roemer & Schultes (Syst. Veg. 1817) by Blume (Cat. Gew. Buitenzorg 37. 1823), to J. E. Smith by Dillwyn (Rev. Hort. Mal. 13. 1839) and Hasskarl (Nova Acta Akad. Leop.-Carol. **33**: 29. 1867). *F. venosa* Ait. as reported by Voigt (Hort. Sub. Calcuttensis 287. 1845) is *F. lacor* Ham.

Pella ribesioides Gaertn. was proposed as a synonym in Trimen (Handb. Fl. Ceylon **4**: 91. 1898). Gaertner located this genus between *Vaccinium* and *Grossularia*. His plate shows small fruiting bodies clustered on tubercles. A cross section of one body reveals the absence of partitions and the presence of fruits or seeds borne on the inside wall. The vernacular name *Kiripoella*, cited by Gaertner, evidently was the source of the generic name and is almost the same as that in Trimen's text for *F. tsjahela*.

F. infectoria Willd., a name almost as much-used as *F. venosa* Ait., has been a source of great confusion. In 1804 Willdenow (Hort. Berol. fasc. **3**: 36. *pl. 36*) described and illustrated a species of *Ficus* with conspicuously veined leaf-blades. This he asserted to be *F. venosa* Ait. By 1806 he had discovered that he was mistaken; but he retained Aiton's appropriate name for the tree pictured, and re-christened *F. venosa* Ait. as *F. infectoria*, with *Tsjahela* as another synonym. Willdenow's appropriation of *F. venosa* was recognized as illegal by Poiret (Encyc. Suppl. **2**: 654. 1812), who re-named the tree *F. leucantatoma*. This was spelled *leucatoma* by Roemer and Schultes (Syst. Veg. **1**: 501. 1817).

Poiret's mention on p. 657 of *F. venosa* Ait., to which he returned *F. infectoria* Willd., is worth noting because of a reference to it by Hamilton in 1827, and because Poiret included "*Ficus tsjakela* Rheede" as a synonym, as Vahl (Enum. Pl. **2**: 185. 1806) had done.

F. infectoria Willd. often has been confused with *F. infectoria* Roxb. Roxburgh (Hort. Beng. 66. 1814) listed a tree of Bengal as *F. infectoria* (no author). That he believed this to be *F. infectoria* Willd. was shown by his reference to *Tsjahela* Rheede. Later (Fl. Ind. ed. 2, **3**: 551. 1832) he described his Bengal plant as *F. infectoria* Willd., and referred to both *Tsjahela* and *F. tsjahela* Burm.f. However, his description showed that his plant was a new species. When *F. infectoria* Willd. was proved to be an illegal title its specific name, equally illegally, came to be transferred to Roxburgh's tree with Roxburgh's authorship, and has persisted almost to the present time. In recent years *F. lacor* Ham. has been recognized as its valid title. The following writers have used the name *F. infectoria* Willd., and sometimes its synonyms, for *F. lacor:* Wight (Ic. Pl. **2**: *pl. 665.* 1843), Beddome (Fl. Sylv. India **2**: 222. 1874), Brandis (For. Fl. India 414. 1874). Kurz (above, 446–447), and Trimen (Syst. Cat. Pl. Ceylon 84. 1885).

Wallich's catalog of 1831 listed no. 4519 as *F. venosa* Ait. Subdivisions *A*, *F. infectoria* Hb. Wight, and *B*, an unamed *Ficus* from Heyne's herbarium are specimens of *F. tsjahela,* according to King (1887). It is disconcerting to find that Wight's specimen belongs here, since his illustration of "*F. infectoria* Willd." is obviously of Roxburgh's species and often is cited as a reference therefor.

Hamilton (Trans. Linn. Soc. **15**: 150. 1827) in an attempt to establish the identity of *Tsjahela* Rheede added another problem. Saying that the plant which he considered was that species did not conform to the description by Willdenow, he described it as *F. venosa*, alluding to Poiret's text (which had cited the author as Aiton), and listing Roxburgh, Burman, and Rheede as references. Most of his characterization applies equally well to both *F. tsjahela* and the variable *F. lacor*. The short petioles and twin figs resemble the latter rather than the former species, but the absence of aerial roots and the maturing of the figs on defoliated twigs point towards *F. tsjahela*, where it has been placed by King (1887). Miquel (Ann. **3**: 286. 1868) and in earlier writings believed that *F. venosa* Ham. was *F. infectoria* Roxb., although he never seemed sure whether or not this species was also that of Willdenow. Haines (Bot. Bihar & Orissa **5**: 832. 1924) has thought that Hamilton's plant might be a form of *F. infectoria* Roxb. or else *F. geniculata* Kurz. In fact, Haines placed *F. tsjahela* close to, if not under, *F. geniculata.*

The synonym *F. indica* Moon was suggested in Trimen's text of 1898 with the note: "not L." I have not seen Moon's book, which includes also *F. bengalensis* L., the accepted name for the ill-defined *F. indica* L.

Miquel (1847) transferred *F. tsjahela* Burm.f. to *Urostigma*, a genus derived from *Ficus* by Gasparrini, describing the species from specimens obtained in southernmost India; and characterized also as new species *U. caulobotryum* from the "East Indies" and *U. ceylonense* from Colombo. The three descriptions differ only slightly. Miquel (Ann. p. 287) returned *U. tsjahela* and *U. caulobotryum* to Ficus. *U. ceylonense* he placed (Ann. pp. 264, 286) under the present *F. lacor*, although he had stated one of its vernacular names to be *Kiripaella*. These three species of *Urostigma*, and *F. caulobotrya*, were allocated to *F. tsjahela* by King. Some mistakes in their names are: *U. caulobotryon* by Dietrich (Syn. Pl. **5**: 554. 1852), *U. caulobotrya* by King (1887) and Gagnepain (in Lecomte, Fl. Gén. Indo-Chine **5**: 761. 1928), *U. ceylonese* by King (1887), *F. caulocarpa* Miq., instead of *F. caulobotrya*, by King (1888).

U. infectorium Thwaites is included in this synonymy because certain numbers of Thwaites' specimens with that name and Miquel as author belong to *F. tsjahela,* according to Trimen (1898).

UNRELATED SPECIES

F. tjiakela Hb. Hook. was allocated by Miquel first to *U. rigidum* Miq. and then to *F. rigida* (Miq.) Miq. Ann. Mus. Bot. Lugd.-Bat. **3**: 286. 1867.

Covellia venosa (Willd.) Miq. is *F. leucantatoma* Poir.

SUMMARY

Ficus tsjahela Burm.f. was named from a pre-Linnean species from the west coast of India. Its name in the original text was misspelled and its illustration was mislabeled. The former mistake, although corrected in the same volume, seems to have passed almost or quite unobserved; the fault in the label was soon noticed.

For nearly 120 years the name proposed by Burman was almost ignored except as a synonym, and the tree usually was called either *F. venosa* Ait. or *F. infectoria* Willd. Both titles were applied also to other plants. The resulting confusion, although not the orthography, was straightened out by King in 1887, and a synonymy prepared. Since that time Burman's seems to have been the only name used.

The preceding study has collected and discussed synonyms listed by King and others, has differentiated *F. tsjahela* from the type of *F. lacor* Ham. and from *F. geniculata* Kurz, and has corrected some mistakes in determination, authorship, and spelling. Herbarium specimens have been examined at the New York Botanical Garden, and literature there and at the Arnold Arboretum, Jamaica Plain, Mass. I am grateful for the use of these facilities and for help given me by those in charge of them.

MONTCLAIR, NEW JERSEY.

BULLETIN OF THE TORREY BOTANICAL CLUB
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TORREYA

EDITORIAL NOTE

With the closing of volume 45 TORREYA ceases to exist as a separate publication. It will be continued as a section in this and subsequent issues of the BULLETIN.

TORREYA originated in a resolution presented at the annual meeting of 8 January 1901. "The space of the BULLETIN being now wholly needed for technical matter," it was resolved "that the publication by the Club of a monthly periodical is desirable, to contain short articles and notes with special reference to the study of the local flora, thus covering the ground occupied by the BULLETIN at its establishment in 1870" (Bull. Torrey Club **28**: 190, 191. 27 Mr 1901). Book reviews also were included, and the *Proceedings of the Club* were transferred to the new periodical in its second year (1902).

In view of the greatly increased costs of publication, it has seemed impracticable to continue to issue a separate periodical for these purposes. It is relevant also that the supply of short articles of the kind contemplated by the founders of TORREYA has been very limited; indeed from the beginning, TORREYA included as many "technical" papers as those "of a popular nature."

For these reasons the Club has voted to merge the two periodicals. The name of the younger, TORREYA, will be preserved at the head of a special section of the BULLETIN, designed to include such materials as: short floristic notes, chiefly of local interest; book reviews; news items; proceedings of the Club. In this way the problem presented in the resolution of 1901 may be solved in a different way.

Somewhat longer papers of a technical nature, such as have often been included in TORREYA, will take their proper places among the papers regularly published in the BULLETIN.—H. W. RICKETT

SHORT ARTICLES AND NOTES

Notes on the Mosses and Lichens of the Great Swamp (New Jersey).[1]

The Great Swamp of New Jersey is located in the southeastern corner of Morris County. Since January 1944 the authors have been conducting an ecological survey of a half-mile-square area in Chatham Township. This area may easily be located, since the northern boundary consists of a road known as Southern Boulevard, which starts at the point where the Public Service Company's power line crosses it and continues west one-half mile. The eastern boundary follows the west side of the power line one-half mile south. Within the area all types of ecological habitats are found. Near the northern boundary are dry sandy soils composed of glacial till and along the southern boundary are soils very acid and rich in peat.

MOSSES

The following mosses we collected in the survey area, the majority of which were growing on the higher ground. We are greatly indebted to Miss Frances Wynne of the New York Botanical Garden for determining this material.

---

[1] Third contribution to an ecological survey of the Great Swamp.

Polytrichum piliferum Hedw. 2–IV–44.
Polytrichum commune Hedw. 2–IV–44, 18–IV–44.
Mnium cuspidatum Hedw. 10–IV–44.
Ditrichum pusillum (Hedw.) E. G. B. 10–IV–44, 18–IV–44.
Dicranum bonjeani DeNot. 10–IV–44.
Dicranella heteromalla (Hedw.) Schimp. 18–IV–44.
Heterophyllium haldanianum (Grev.) Kindb. 18–IV–44.
Mnium affine Bland. 18–IV–44.
Eurhynchium strigosum (Hoffm.) B. and S. 18–IV–44.
Pohlia nutans (Schreb.) Lindb. 18–IV–44.

LICHENS

So far we have only collected lichens growing in the grasslands. On the northern end of the survey area, opposite the Chatham Township Public School, is a series of eleven fields running north to south. Growing in these fields we found *Cladonia cristatella* Tuck. and *Cladonia grayii* Nearing. These two species were growing together on gravelly glacial till with a pH of 5.17. Associated with the lichens were grasses and a few herbs. This soil is very poor in plant nutrients as indicated by the very slow invasion of woody plants. On March 11, 1944, the authors denuded a square meter on which *C. cristatella* and *C. grayii* were well established and on June 9, 1945, the quadrat was still barren, in spite of the fact that both species of lichen were growing at the edges of the quadrat.

We are greatly indebted to Mr. William L. Dix of Morrisville, Pennsylvania, for determining the lichen specimens.—WILLIAM F. RAPP, JR., AND JANET L. C. RAPP.

Lippia lanceolata and other Unusual Plants at Cross Lake, New York.

On August 25, 1945, while we were returning from a field trip, with a group of graduate students, a short stop on the west shore of Cross Lake in central New York at once yielded a patch of *Lippia lanceolata* Michx., the fog-fruit. It was growing on damp ground near the shore among *Panicum agrostoides* Spreng., *Scirpus americanus* Pers., *Lythrum salicaria* L., and other species in lesser abundance. The very unfavorable weather prevented stopping longer to make a more extensive study of the area at that time.

The manuals state the range of *Lippia lanceolata* as New Jersey to southern Ontario and Minnesota and southward to Texas and Florida. Actual records of its occurrence between southern New Jersey and Michigan seem to be rare. House[1] does not list *Lippia lanceolata* from New York State. Because the Cross Lake station appears to be isolated at some distance from the nearest recorded stations in New Jersey, Ohio and Michigan, another trip was made to ascertain the abundance and range of Lippia in that area.

On September 5, accompanied by Dr. R. T. Clausen and Miss Gertrude Miller we visited Cross Lake again, spending most of the day exploring much of its shoreline vegetation as well as dredging from boats for aquatic species. This survey revealed that *Lippia lanceolata* is rather generally distributed in low wet ground along much of the eastern and western shores of the lake and also along the Seneca river

[1] House, H. D. Flora of New York. N. Y. State Mus. Bull. 254. 1924.

where it leaves the lake. In several places *Lippia* forms dense mats covering extensive areas near shore. None was found more than 300 feet from the water's edge. Most of the plants were sterile but a number of flowering and fruiting plants were observed on the higher places back from shore. The plants were mostly decumbent, or with erect branches when crowded, rather than prostrate or creeping as they so often occur in the southern states.

Cross Lake is partly in Cayuga county and partly in Onondaga county. It is about 5 miles long. Its elevation is 375 feet above sea level according to the U. S. Topographic Survey map. Its south end is traversed by the Seneca river which here is canalized and used by the Barge Canal. Most of the shore and much of the bottom of the northern part of the lake is composed of soft marl and broken shells.

The following plants rarely found in central or western New York, were also collected in or around Cross Lake on August 25 or September 5, 1945.

PANICUM AGROSTOIDES Spreng. Common on wet shores along Cross Lake and the north shore of the Seneca river where it leaves the lake; in Cayuga and Onondaga counties.

ACNIDA CANNABINA L. On muddy banks of the Seneca river just west of the lake; Onondaga county.

AZOLLA CAROLINIANA Willd. Floating among *Lemna minor* L. in a sluggish inlet entering the lake through a bog near the northwest corner; Cayuga county.

NAJAS MINOR Allioni. In shallow water near shore and also dredged in deeper water in several places off the east shore of the lake; Cayuga county.

The occurrence of this heterogeneous assemblage of plants, otherwise unknown or known from but few stations in central or western New York, is a subject for speculation. How did they arrive in Cross Lake and why did they become established there? Or are some of them indigenous there? Probably no one answer will suffice for all of the five species mentioned. However, the fact that Cross Lake is a mecca for fisherman and is traversed by much water traffic between Lake Erie and the Hudson River must not be overlooked in searching for explanations for the appearance of these plants in Cross Lake. The non-acid soil along most of the shore line and a rather constant and controlled water level during the summer months may furnish here a more favorable habitat for these species than occurs elsewhere in western New York.

Specimens of all the species mentioned have been collected by us and have been deposited in the herbarium of the Department of Botany at Cornell University.—W. C. MUENSCHER AND BABETTE I. BROWN.

PROCEEDINGS OF THE CLUB

Minutes of the Meeting of May 16, 1945. The meeting was called to order by President Seaver at 3:30 p.m. at The New York Botanical Garden with fourteen members and friends present. The minutes of the preceding meeting were approved as read.

The secretary read the report (attached to these minutes) of the committee appointed to compose a congratulatory message to The New York Botanical Garden. The report was accepted as read. Dr. Karling reported that the message was to be engraved by the Columbia University Press.

The president read an invitation from the Biological Laboratory of Fordham University to the Club to attend the ceremony, on May 24th, conferring the honorary degree of Doctor of Science upon Dr. William J. Robbins.

Dr. J. T. Baldwin, Blandy Experimental Farm, Boyce, Va., was elected to life membership in the Club. One annual member and one associate member were also elected.

Dr. Karling made a motion requesting affiliation of the Torrey Botanical Club with the Union of American Biological Societies. Dr. Cronquist seconded the motion. There was some discussion concerning the advantages and obligations attendant upon such an affiliation. The motion was carried unanimously.

Miss Hanson raised the question of granting a discount on subscriptions on back sets of the BULLETIN to book-sellers or agencies. Dr. Karling moved the appointment by the president of a committee of three: the editor, the business manager, and the treasurer, to investigate this question and decide upon a policy. Dr. Levine seconded the motion and it was carried.

The business meeting adjourned at 4: 00 p.m. to the lecture hall for an interesting and instructive program by Dr. A. B. Stout on "Types of Intra-specific Incompatibilities."

The speaker's abstract follows:

> In respect to the locus of sexual reproduction in the life cycle and to the scope, action, and genetics of the modifying factors of incompatibilities, there are three distinctive main classes of incompatibilities which may be designated as follows:
>
> I. *The diplont-haplont class.* In the flowering plants the inhibiting effects of self- and cross-incompatibilities occur chiefly during reactions between the diploid tissues of the pistils of flowers of the sporophytic generation and the haploid pollen tubes of the alternating gametophytic generation.
>
> II. *The haplont-haplont class.* In the fungi the reactions of incompatibilities occur in the interrelations between individuals that are haploid, bisexual and gametophytic.
>
> III. *The diplont-diplont class.* In the ciliates among animals the reactions of incompatibilities operate chiefly in the relations of selective conjugation between individuals that are bisexual and diploid and hence comparable to the sporophytic generation in plants.
>
> The incompatibilities noted in this presentation are selective limitations to the sexual reproduction of homomorphic hermaphrodites. They limit or prevent both self-reproduction and intra-genotypic cross-reproduction. They effect inter-genotypic intra-specific reproduction.
>
> Incompatibilities operate by inhibiting certain of the physiological interactions that are essential to sexual reproduction but which are not features of nuclear or gametic sexuality.
>
> Pollen-tube reactions in the pistils of flowering plants, fusions of mycelia and spermatial fertilizations in fungi, and conjugations between individuals of ciliates are all stabilized reactions of intraspecific sexual reproduction. When there are no incompatibilities there is unrestricted interaction in these features of intraspecific reproduction. Incompatibilities are superimposed on these mechanisms and they effect certain failures in interactions which would otherwise occur.
>
> Incompatibilities are genetically determined by factors which segregate in meiosis. In the homomorphic bisexual members of a population they may be the only feature of sexuality that does segregate in meiosis. This situation has not been recognized in many considerations of sexuality especially in the fungi.
>
> The simplest mode of incompatibilities is that which is determined by a single allelic pair of factors (personate mode) operating in haplont-haplont relations. Then there may be only two mating groups. A minimum number of multiple alleles in a haplont-haplont relation is three. In all the classes there may be numerous multiple factors and numerous mating genotypes. Further complexities involve two or more allelic series (a) of incompatibility factors (amphipersonate) or (b) of one such series in complementary relations with factors which favor fertility (associate mode) or of more than one series of each (amphiassociate).
>
> The basic incompatibility reaction is evidently one of independent self-antagonism. But the presence of two or more different factors enforces various types of complementary and competitive reactions.

In addition to incompatibilities there are other methods of preventing self- and intra-genotypic reproduction and of enforcing bigenotypic reproduction in hermaphrodites. (a) There are herkogamy and dichogamy which operate to separate elements of sexual reproduction previous to their interaction. (b) There are the conditions of polymorphism, especially developed in dimorphic and trimorphic species of flowering plants, in which incompatible reactions are correlated with morphological features.

It is of course to be recognized that in any truly dioecious species the reproduction of the unisexual individuals is obligated bigenotypic.

Intraspecific incompatibilities operate with remarkable similarity in phanerogams, in fungi, and in ciliates. Differences in the locus of sexual reproduction in the life cycles of these diverse and phylogenetically widely separated groups of organisms are reflected in three distinct classes of expression and genetic control which may be designated (I) haplont-diplont, (II) haplont-haplont, and (III) diplont-diplont. Without doubt future studies in the groups mentioned and in other groups of plants and animals that were not mentioned will reveal further modes or even other classes of reaction and determination.

After the scientific program the members were served tea by the Garden Staff in the Members' Room.

Respectfully submitted,
Frances E. Wynne,
Recording Secretary

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CARLTON CLARENCE CURTIS
1864–1945

EDWIN B. MATZKE

Professor Carlton C. Curtis wove his life inextricably into the science of botany, to which he was completely devoted, and into Columbia University, which he served long and faithfully. Through his efforts, both the science and the University have been deeply enriched.

Carlton Clarence Curtis was born near Syracuse, N. Y., in 1864. His early training was at Syracuse University, from which he received his bachelor's degree in 1889, and at Columbia University, which awarded him the master's degree in 1892. He then returned to Syracuse for the doctorate in 1893. Subsequently he studied at the University of Cambridge in England, where he was associated with Francis Darwin, and at the University of Leipzig in Germany, where he worked under the brilliant plant physiologist Pfeffer. The training which he received under these two men is reflected in his publications in the field of plant physiology.

For two years Dr. Curtis was principal of Fayetteville Union School, N. Y., and for two additional years he was an instructor in natural science in Brooklyn Polytechnic Institute, N. Y. In 1892 he was appointed assistant in Columbia University, and from that year until his retirement in 1934 he was associated with its Department of Botany; it was there that he did his life work.

The published material of Dr. Curtis covers a wide range of topics and attests the catholicity of his interests. His earliest investigations dealt with the structural and cellular features of orchid seeds and their significance in classification. He then made careful studies of the early stages in the development of the lichen thallus, and followed these with an account of algae characteristic of New York harbor. In 1898 he published a lucid discussion of the evolution of assimilating tissue and the fundamental nature of the leaf in the plant kingdom. During the early years of the twentieth century, Professor Curtis turned his attention largely to the young and growing science of plant physiology. In a series of experiments he analyzed turgidity in the hyphae of fungi under controlled and varying environmental conditions. Next there followed a series of studies on transpiration. The work performed by the plant in transpiration was computed, and subsequently the daily transpiration curve in light and in darkness and correlated stomatal activity were recorded and interpreted. He then studied the characteristics of etiolation developed by plants growing in feeble light. Professor Curtis also pub-

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lished an article on successive flowering of the tulip tree in one season, and another on the conifers of the northwest. From a consideration of his investigations, it is evident that his research interests were unusually broad. During these years he also prepared numerous book reviews.

Professor Curtis published three books. The first, *A textbook of general botany*, appeared in 1897; this was modestly intended as "an exposition" of the laboratory work required of beginners at Columbia, but it is a sizable, complete and well-illustrated volume. The second book, *Nature and development of plants*, was first put out in 1907, and has gone through numerous editions and printings. It has been used widely as a text-book in elementary courses in botany in colleges and universities throughout the United States. It is written in pleasant literary style, and in this respect is entirely different from the stilted approach so characteristic of scientific text-books. *Nature and development of plants* was a superior presentation of the whole field of botany; the second part of this work, dealing with the plant kingdom, is still unsurpassed as a brief discussion of the groups of plants. Dr. Curtis' third book, *A guide to the trees*, appeared in 1925. Although complete treatises on the trees of northeastern North America were available, this was intended as a brief but scientifically accurate guide, written in language which could easily be understood. The drawings were made by Mrs. Curtis. This volume has also had wide use and has passed through numerous printings. It is of course distinctly unusual for a man trained in physiology to write a successful book on trees. But Professor Curtis was thoroughly familiar with plants in the field; he personally assembled the sizable herbarium which is now used as the teaching herbarium of Columbia University. In a way achieved by few men, Dr. Curtis was a general botanist, specifically trained in various fields, and capable of seeing the plant as a whole and of visualizing the problems connected with it in three dimensions.

This breadth of outlook and training was to a considerable extent responsible for his remarkable success as a teacher; for in spite of his accomplishments as a scientist and as an author, his greatest achievement was probably in the classroom. Dr. Curtis taught the large general course in elementary botany throughout his long period of association with Columbia University. For many years he conducted the graduate work in plant morphology; he also gave a course in Columbia College on algae, and another in the School of Engineering on trees and timbers. Dr. Curtis' lectures were always carefully prepared, delivered in fine English, and touched with humor. The thousands of students who passed under his tutelage respected him for his learning, admired him for his ability as a teacher, and sought his counsel because of his sympathetic and human understanding.

Dr. Curtis joined the Torrey Botanical Club in 1892. For more than twenty years he was one of its very active members, frequently reporting on the program and serving in sundry capacities. He was treasurer in 1906 and 1907, and associate editor from 1898 to 1902; he served on the program committee for two years, on the committee on admissions for four years, and on the local flora committee from 1909 to 1920. He was elected to life membership in 1934. He was also a member of Phi Beta Kappa, Sigma Xi, and numerous scientific societies.

In his earlier years Dr. Curtis was a man of buoyant disposition and keen good humor, animated, energetic, and with a wide circle of friends. He was always interested in camping and fishing; even in later years he could cast a fly with fine precision, and his skill with a rifle never left him. He liked to spend his spare hours in the field. Sometimes on foot and sometimes by canoe, he would disappear into the vanishing wilderness in various parts of the United States and Canada to seek refreshment. When he was no longer vigorous enough to do this, he built simple cabins—always beyond the end of the trail, and there he studied plants and birds under undisturbed conditions. Dr. Curtis was an accomplished naturalist; he kept records and made observations in the field for many years, and he had a keen appreciation of plant and animal life, in which he never lost interest.

Unlike most scientists, Professor Curtis was widely read in literature, in the Bible, and in world affairs. Poetic and sensitive by nature, he had a natural appreciation of good literature. He traveled extensively, not only in North America, but in little-frequented parts of Europe, and in the Holy Land. Even in his advancing years he was still the witty, animated, brilliant conversationalist, with an almost endless fund of true stories, drawn mostly from his own experiences. His broad scientific training, his interest in wild life, his appreciation of literature, his wide travels, his sense of humor, and his forceful personality all blended to make him a man of unusual richness and charm. Although thoroughly kindly, he was strong in his conviction of right and wrong, completely impatient with sham and pretext, and unwilling to mince his words. Such men frequently suffer internally in an imperfect world.

Professor Curtis spent more than ten years in idyllic retirement. He continued to travel to some extent, but lived mostly at Tryon, North Carolina, where the Blue Ridge Mountains roll away from the Piedmont. Here he and his wife, Ellison Gwyn Curtis, built an unpretentious but attractive home, facing the mountains. They were singularly blessed in having in common similar philosophies of life, love of good literature, interest in plants and birds, appreciation of the beautiful, fondness for camping, fishing, and travel, and a sense of humor.

Professor Curtis died at his home at Tryon on April 10, 1945. In his passing the science of botany lost one of its greatest teachers and one of its finest scholars. His long and fruitful life was one of rich accomplishment and noble simplicity. The letters which so many of his students have written are at once a mark of the esteem in which they held him and a tribute to the inspiration which he afforded them. They all speak of him in similar terms, as one who was a thorough gentleman, whose life reflected the quiet greatness of his soul.

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FURTHER STUDIES ON THE ERYSIPHACEAE OF CHINA[1]

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Taxonomic work in fungi is usually done with herbarium material. Most of the taxonomists still cling to the old conception of the rigidity of species. Allowance is not, as a rule, duly made for the effect of environment and host on the variation of morphological characters. Salmon is conservative in species limitation, recognizing in his monograph of the Erysiphaceae (Mem. Torrey Club **9**: 1–292. 1900) only 49 species and 11 varieties for the whole world. The fact that Salmon's monograph has remained the standard work for so many years is not without reasons. After many years' study on the Erysiphaceae of China both in the field and in the laboratory the writer has come to believe that a broad view on species limits should be taken.

This paper gives mainly results of careful comparative studies of all available collections of most of the species of Erysiphaceae so far reported from China. It seems advisable and proper to keep the collective species: *Erysiphe Polygoni*, *Erysiphe Cichoracearum* and *Microsphaera Alni* as emended by Salmon. One variety of *Erysiphe*, two species of *Microsphaera* and one species and one variety of *Uncinula* are described as new.

SPHAEROTHECA FULIGINEA (Schlecht.) Pollaci.

On *Bidens bipinnata*, FUKIEN: Shaowu, *Loh 16,221*. On *Cosmos bipinnata*, YUNNAN: Kunming, *6362*.[3] On *Cucurbita Pepo*, YUNNAN: Kunming, *7582*. On *C.* sp., YUNNAN: Kunming, *4051*; Chengkiang, *4048*. On *Hibiscus mutabilis*, YUNNAN: Kunming, *7218*, *8022*. On *H. syriacus*, YUNNAN: Kunming, *8016*. On *Impatiens Balsamina*, YUNNAN: Kunming, *4110*; Tali, *4109*; FUKIEN: Shaowu, *Loh 16,523*. On *Taraxacum orientale*, HOPEI: Kalgan, *Wu 113*.

Perithecial stage rarely occurs on members of the Cucurbitaceae. *Erysiphe Cichoracearum* has been recorded on them in Europe, North America, and Japan; *E. Humuli* in Europe (Marie, R., Bull. Soc. Mycol. Fr. **46**: 231. 1930) and *Sphaerotheca fuliginea* in Central Europe, Russia, and Japan. In China only *Sphaerotheca fuliginea* has been so far found on *Cucurbita Pepo* (Sinensia **3**: 98. 1932). In a previous publication (Tsing Hua Univ.

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[2] The writer wishes to acknowledge his indebtedness to the following gentlemen for sending specimens for this study: Professors L. T. Lin, Tsing-tsuh Loh; Drs. C. S. Wang, H. K. Chen, L. Ling and C. T. Wei; Messrs. Y. S. Wu and W. L. Hsian, and especially to Mr. C. Y. Wu for identifying host plants.

[3] This refers to the Tsing Hua Pathological Herbarium number for additional collections mostly made in Yunnan since 1939.

Inst. Agr. Res. Bull. **6**: 22. 1941) the writer has referred the powdery mildews on *Cucurbita* sp. and *Momordica charantia* collected in the province of Yunnan to *Erysiphe Cichoracearum,* relying at that time on the erroneous determination of the conidial stage. Since then perithecia have been found, on re-examination, on two of the collections, nos. 4048 and 4051. The fungus again proves to be *Sphaerotheca fuliginea:* perithecia 89–106 μ in diameter; cells of the perithecial wall 17–29 μ wide, mostly above 21 μ; asci subglobose or broadly ovate, 69–91 × 57–69 μ; spores 16–20 × 11–16 μ. Conidia in chains, 29–34 × 20–21 μ with fibrosin bodies.

SPHAEROTHECA LANESTRIS Harkness.

On *Lithocarpus dealbata,* YUNNAN: Kunming, *4111*. On *Quercus Delavayi,* YUNNAN: Kunming, *7237*.

The occurrence of this species in China was reported by the writer in 1935 (Bull. Ch. Bot. Soc. **1**: 13. 1935). In the collections of powdery mildew made at different places in the province of Yunnan, a form of *Sphaerotheca lanestris* with evanescent mycelium has been found on *Lithocarpus dealbata* and *Quercus Delavayi:* hypophyllous; mycelium evanescent; perithecia subgregarious in spots, 90–114 μ in diameter; appendages usually obsolete or few, short, branched, thick-walled, hyaline, at the base of the perithecium; asci at first fusiform, becoming broadly ovate or subglobose after absorbing enough water, 86–105 × 63–75 μ; spores ellipsoid or oblong, 24–31 × 16–20 μ. The fusiform asci, when not fully expanded, measure 114–157 × 54–63 μ. A novice would consider the present plant as a distinct species if he took the fusiform, not fully expanded asci as typical. (Fig. 1.)

The writer re-examined specimens of the collection, *Cheo 2851*, collected by Mr. S. Y. Cheo in Kwangsi, which had been referred to *Sphaerotheca lanestris* in 1935 (l.c.) as above mentioned, and found that the fully expanded asci measure 77–100 × 60–66 μ and are also broadly ovate or subglobose in shape. The Yunnan form on *Lithocarpus dealbata* and *Quercus Delavayi* is no doubt identical with the former in spite of the fact that its mycelium is evanescent. The character of the mycelium is, therefore, not a constant one in *Sphaerotheca lanestris.*

SPHAEROTHECA PANNOSA (Wallr.) Dav.

On *Rosa centifolia,* YUNNAN: Kunming, *4112*. On *R. multiflora,* YUNNAN: Kunming, *4113*. On *R. rugosa,* KIANGSU: Wusih, U. N. Path. no. 3915.

The plant on *Rosa rugosa* (U. N. Path. no. 3915) was formerly referred to *Sphaerotheca Humuli* (Bull. Ch. Bot. Soc. **1**: 13. 1935). Re-examination of both the perithecial and conidial stages of the original collection shows that the plant should be identified as *Sphaerotheca pannosa.* Its description follows:

Amphigenous; mycelium persistent, thick, effused or forming patches, white at first, becoming gray or brownish, also on petioles; conidia[4] in chains (2–4), cylindrical, with fibrosin bodies, 24–30 × 10–15 μ, conidiophores 4–5-celled, 107–149 × 8.5–10 μ, perpendicular to the hyphae. Perithecia gregarious to scattered, immersed in the persistent mycelium which is thick-walled, hyaline, about 5–6 μ thick, 81–97 μ in diameter; cells of the perithecial wall obscure, 10–16 μ wide (mostly 11–13 μ); appendages few, 1–10, often obsolete, tortuous, thick-walled up to the apex, brownish or only colored at the basal part, hyaline or subhyaline at the upper part, very short (1/5) to twice as long as the diameter of the perithecium, usually short, 3.6–5.0 μ wide, 1-septate at the base; asci globose or subglobose, rarely shortly stalked, 89–104 × 76–83 μ; spores 8, ellipsoid, 27–34 × 16–20 μ.

Two species of *Sphaerotheca* have been recorded on *Rosa* spp.: *Sph. pannosa* and *Sph. Humuli*. *Sph. pannosa* is close to *Sph. Humuli*, but differs mainly in the persistent, thick, and pannose mycelium, the shorter and tortuous appendages, and the larger asci. The conidia of the former species are also much shorter and narrower than those of the latter. On account of these distinct characters the present form is referred to *Sph. pannosa*. In the description of this fungus by Salmon (Mem. Torrey Bot. Club **9**: 66. 1900) the appendages are described as "very short." Those of the present plant are usually short, few, and sometimes obsolete, but often short and long ones occur on the same perithecium, the long ones attaining a length up to twice as great as the diameter of the perithecium.

According to Woronichine (Bull. Trim. Soc. Myc. Fr. **30**: 398. 1914) the appendages of *Sph. pannosa* on peach are 10–15 in number, clear brown and short ("15–30" μ long), but sometimes attaining a length of 70 to 90 μ long (perithecia "70–93.6" μ in diam.). Schwarze in his "Parasitic fungi of New Jersey" (New Jersey Exp. Sta. Bull. **313**: 33. *f. 120.* 1917) stated that the appendages of *Sph. pannosa* are few, very short, and tortuous, but his illustration of the perithecium shows eight colored tortuous appendages which are at least as long as the diameter of the perithecium. From these it is evident that the appendages of *Sph. pannosa* are not uniformly "very short" as stated by Salmon.

SPHAEROTHECA WRIGHTII (B. & C.) v. Hoehnel.

On *Quercus glauca*, FUKIEN: Shaowu, *Loh 16,400.*

Hypophyllous; mycelium persistent, forming definite patches; brown hairs from the mycelium, sickle-shaped or various in shape, occasionally branched, thick-walled to the apex; perithecia 60–74 μ in diameter; cells of the perithecial wall obscure, those of the inner wall 6–15 μ wide; appendages few, 1–4, at the base of the perithecium, tortuous, brown, short (equaling the diameter of the perithecium) and thick-walled; asci broadly ovate, 57–71 × 44–54 µ; spores ellipsoid or ovoid, 17–23 × 11–16 µ.

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[4] According to Mlle. Bouwens (Phytopath. Lab. Willie Commelin Scholten Meded. 8: 3–47. 1924) the average length of the conidia of *Sph. pannosa* varies between 22.92 and 28.68 μ, the average width between 13.63 and 15.81 μ. Conidia of *Sph. Humuli* including *Sph. fuliginea* were found by her to vary in length between 26.65 and 39.89 μ and in width between 16.22 and 22.26 μ.

Sphaerotheca Wrightii is distinct from *Sph. lanestris* by the presence of the brown, sickle-shaped hairs, smaller perithecia, asci, and spores.

Podosphaera leucotricha (E. & E.) Salmon.

On *Malus spectabilis*, Yunnan: Kunming, *5258*.

This fungus is common at Tapugi, Kunming, and causes serious disease in *Malus spectabilis*. The perfect stage has not yet been collected. Its conidial stage is as follows: mycelium amphigenous and caulicolous, persistent, thick, effused; conidiophore 4–5-celled, 74–114 × 8.6–11 µ; conidia in chains, ovoid, broadly elliptic or oblong, containing fibrosin bodies, 21–23 × 14–19 µ.

Podosphaera Oxyacanthae (DC.) de Bary.

On *Crataegus scabrifolia*, Yunnan: Kunming, *7927*.

Only the conidial stage was collected. It shows the following characters: mycelium amphigenous, persistent, forming definite patches; conidiophores 5–6-celled, 129–200 × 7–9 µ; conidia in chains, ovoid or oblong, 20–27 × 10–13 µ.

Podosphaera tridactyla (Wallr.) de Bary.

On *Prunus Persica*, Yunnan: Kunming, *7910*.

Amphigenous, mainly hypophyllous; mycelium evanescent; perithecia scattered to gregarious, cells of the perithecial wall obscure, 8.6–11 µ wide, 83–90 µ in diameter; appendages 2–4, septate, 3–5 times dichotomously branched at apex; ultimate branchlets recurved; asci 59–70 × 57–64 µ; spores 19–27 × 13–17 µ.

Erysiphe Cichoracearum DC. *E. Plantaginis* (Link) Sawada, Agr. Gov. Res. Inst. Formosa Report No. **24**: 49. 1927. *E. tabaci* Sawada, Ibid.: 43. 1927. *E. lamprocarpa* (Wallr.) Duby in Blumer-Beiträge Kryptogamenflora der Schweiz **7** (1): 275. 1933.

On *Nicotiana tabacum*, Yunnan: Kunming, *4053*, *4137*, *5255*; Shihping, *6940*; Tachwang, *4054*. On *Plantago major*, Yunnan: Kunming, *4103*.

Sawada (l.c.) and Blumer (l.c.) restored the form of the collective species, *Erysiphe Cichoracearum*, on the genus *Plantago* to specific rank, and named it *E. Plantaginis* and *E. lamprocarpa* respectively as a result of cross-inoculation experiments and on minor morphological differences. In a study of the conidial stage of species of *Erysiphe* in Formosa, Sawada found that the conidiophores of that genus could be divided into three types: (1) conidiophore perpendicular to the hypha without enlargement at the base: forms on tobacco, poppy, *Leonurus sibirica* and *Leucas javanica* have this type of conidiophore; (2) conidiophore arising from the side of the hypha with its basal part curved: forms on *Plantago*, *Lactuca debilis*, *Sonchus* *arvensis,* etc.; (3) conidiophore perpendicular to the hypha with the basal cell enlarged: *E. graminis. E. Plantaginis* was separated by Sawada from the other forms of *E. Cichoracearum* mainly by its inability to infect hosts other than *Plantago major,* and the curved basal part of the conidiophore. Regarding the latter the present writer has found perpendicular conidiophores in the form of *Erysiphe Polygoni* on *Pisum sativum,* but curved conidiophores in that of the same species on *Vicia Faba* in the material collected at Kunming. From this it is clear that this minor morphological difference of the conidiophore is not of sufficient importance for differentiating species.

Blumer (l.c.) stated that *E. lamprocarpa* differs from other forms of *E. Cichoracearum* sensu lato by its very numerous and short appendages as well as its long and narrower conidia ("35–39" μ long, "16–19" μ wide). On re-examination of the Chinese form of *E. Cichoracearum* on *Plantago major* and also of fresh material of the conidial stage, it has been found that the number of appendages varies from 20 to 60 or more. Short and long ones occur on the same perithecium measuring from (37)100 to 294 μ in length. They are never uniformly short and numerous. Sawada described the appendages of the Formosan form as several in number, long and short on the same perithecium, measuring 36–200 × 8 μ. The size of the conidium of the Chinese form, according to the measurements of the writer–26–40 × 14–18 (21) μ–, is very close to that of Blumer and Sawada. But the conidium of a form of *E. Cichoracearum* on tobacco collected at Kunming is practically of the same size as that of the fungus on *Plantago:* 26–41 μ long, 14–18 μ wide.

The conidiophore of the form on tobacco and poppy is said to be perpendicular to the hypha. On that account this form was raised to specific rank by Sawada as *E. tabaci.* It is similarly untenable for the reason already stated.

It is of interest to note that *E. Cichoracearum* has been recorded on *Helianthus annuus* in Europe, North America, and Japan, while in their studies of Erysiphaceae of China Wei and the present writer have so far only found *E. fuliginea* on that host plant. Teng also reported the same species on the latter (Contr. Biol. Lab. Sc. Soc. China **8**: 7. 1932). Although *E. Cichoracearum* has been reported on *Helianthus annuus* from this country by Chu (Jour. Agr. Assoc. China **54**. 1927) this report might have been based on the conidial stage alone, for the conidium of *E. Cichoracearum* is often separated with difficulty from that of *E. fuliginea.* In the Tsing Hua Pathological Herbarium there is one collection of *Erysiphe,* no. 4052, on *Helianthus annuus* collected at Chengkung and identified as *E. Cichoracearum* by Prof. L. T. Lin. The writer did not succeed in finding any perithecia on specimens of that collection and suspects that this fungus also might be *E. fuliginea.*

Erysiphe graminis DC.

On *Triticum aestivum*, Yunnan: Kunming, *7957; * Chengkung, *4057, 4056;* Tachwang, *5330;* Mengtze, *5331, 5354;* Jautung, *4060;* Tungchuan, *4061;* Hsungtien, *4062;* Kwangtung: Canton, *4059;* Shensi: Yen-an, *Wu 1000.* On *Hordeum vulgare*, Yunnan: Kunming, *5367;* Chengkiang, *5318;* Lunan, *5336;* I-Liang, *5342;* Mengtze, *5329.*

Erysiphe Polygoni DC. *E. Glycines* Tai, Lingnan Sci. Jour. **18**: 457. 1939.

On *Amphicarpaea Edgeworthii*, Yunnan: Kunming, *7904, 7606.* On *Begonia yunnanensis*, Yunnan: Kunming, *7921, 7919.* On *B. Evansiana?*, Honan: Sunghsien, *Wang 1915.* On *Castanopsis concolor*, Yunnan: Kunming, *8027.* On *C. Delavayi*, Yunnan: Kunming, *4194, 7204, 7942;* Chengkiang, *5671;* Yuankiang, *6690, 6666;* Merhkiang, *6986.* On *C.* sp., Sikang: Sichan, *8497.* On *Lathyrus palustris*, Yunnan: Kunming, *8151, 8150.* On *Pisum sativum*, Yunnan: Chengkung, *4064;* Fukien: Shaowu, *Loh 18,259.* On *Polygonum nodosum*, Fukien: Yungan, *7518.* On *Plectranthus eriocalyx*, Yunnan: Kunming, *8206.* On *Quercus Schottkyana*, Yunnan: Kunming, *4066, 8018, 8021.* On *Sambucus adnata*, Yunnan: Kunming, *5282, 5283, 5298.* On *Thalictrum reticulatum*, Yunnan: Chichushan, Pinchuan, *4047.* On *T. Delavayi*, Yunnan: Kunming, *7941.* On *T.* sp., Honan: Sunghsien, *Wang 2400.* On *Vicia dasycarpa*, Yunnan: Kunming, *7818.* On *V. Ervilla*, Yunnan: Kunming, *7820.* On *V. Faba*, Yunnan: Kaiyuan, *4063;* Chengkung, *5317;* Kunming, *7556.* On *V. moatha*, Yunnan: Kunming, *7819.* On *V. sativa*, Yunnan: Kunming, *7491.* On *V. tetrasperma*, Yunnan: Kunming, *7290.* On *V. villosa*, Yunnan: Kunming, *7821.*

The appendages of all these collections vary much in length on the same perithecium, and in number on the same specimen. The size of the perithecium and the number of ascospores also vary greatly. All these collections are, therefore, referred to *Erysiphe Polygoni* as emended by Salmon. A careful comparative study has also been made of the other available collections; the characters of these collections grade into one another in such a way that it does not seem feasible to split the collective species, *E. Polygoni*, into many as Blumer has done.

The fungus on *Castanopsis* has relatively smaller perithecia and uniformly very short and numerous basal appendages. But when all its characters are considered as a whole, it is still within the limits of *E. Polygoni* sensu lato. The characters of this fungus follow: epiphyllous; mycelium persistent, effused or forming definite patches; perithecia gregarious to scattered, cells of the perithecial wall 7–13 μ wide, 60–94 μ in diameter; appendages basal, numerous, flexuose-contorted, hyaline or brownish, 1- or mostly non-septate, not branched or 1–2 dichotomously branched at apex, $\frac{1}{2}$ to $\frac{2}{3}$ of the diameter of the perithecium; asci 2–4, broadly ovate or subglobose, with or without a very short stalk, 46–60 × 40–54 μ; spores 5–7, rarely 4 or 8, oblong, 21–29 × 11–14 μ.

A species of *Erysiphe* on *Epimedium* from Honan, although showing affinity with *E. Polygoni*, is remarkable in having larger asci and longer spores. It is here considered as a new variety of *E. Polygoni*:

Erysiphe Polygoni var. **Epimedii** Tai, var. nov.

On *Epimedium* sp., Honan: Sunghsien, 1942, C. S. Wang, *Wang 2520*, type.

A typo differt ascis 64–80 × 36–51 μ majoribus, sporidiis 20–34 × 10–14 μ longioribus.

This variety has larger asci and longer spores. It shows the following characters: hypophyllous; mycelium persistent, effused and arachnoid; perithecia subgregarious to scattered, cells of the perithecial wall 10–14 μ wide, 104–129 μ in diameter (mostly 120 μ); appendages 15–22, 1–5 times the diameter of the perithecium, long and short on the same perithecium, hyaline, not branched, flexuose, hyaline or brownish and thick-walled below, sometimes geniculate; asci 8–12, ovate with a short stalk, 64–80 × 36–51 μ; spores 4–5, usually 5, oblong or subcylindrical, 20–34 × 10–14 μ. (Fig. 2.)

ERYSIPHE sp.

On *Populus Simonii*, SHENSI: Paochi, Sept. 29, 1939, *Y. S. Wu 8489.*

A species of *Erysiphe* was collected on *Populus Simonii* at Paochi, Shensi, by Mr. Y. S. Wu in 1939. Unfortunately the plant is immature. It shows the following characters: epiphyllous; mycelium persistent, dense, effused or forming patches; perithecia subgregarious to scattered, cells of the perithecial wall obscure, 150–181 μ in diameter; appendages numerous, basal, tortuous, usually short to one-half as long as the diameter of the perithecium, hyaline; asci 6–12, broadly ovate to subglobose, 53–57 × 33–41 μ; spores not yet delimited.

MICROSPHAERA ALNI (Wallr.) Winter emend. Salmon.

On *Akebia trifoliata,* HONAN: Sunghsien, *Wang 622.* On *Corylus heterophylla,* HONAN: Sunghsien, *Wang 1061.* On *Castanea mollissima,* YUNNAN: Kunming, *6973;* KWEICHOW: Meitan, *7936.* On *Picrasma quassioides,* SHENSI: Sian, *8297.* On *Quercus acutissima,* KWEICHOW: Meitan, C. U. Path. Herb. no. 461; SZECHUAN: Kwanhsien, *Wei 2187.* On *Q. Fabri,* HUNAN: Changsha, *4079.*

There has been much confusion concerning the identity of the species of *Microsphaera* on *Quercus.* Five species have been described from North America, and one from Europe. The writer has made a careful study of all the available collections of the Chinese forms of *Microsphaera* (list of specimens examined not given for limitation of space) that occur on the genus *Quercus,* and found that they are not identical with any of the species so far described on this genus. The appendages of the Chinese forms are usually shorter than or equal to the diameter of the perithecium (sometimes only one-half as long), and the primary branches are usually much longer than those of other orders. One group of the collections has larger perithecia (108–157 μ in diameter) and larger numbers of asci (5–10, rarely 13) than the others so far examined (perithecia 88–120 μ in diameter; asci 3–7). The mycelium, being either amphigenous, epiphyllous, or hypophyllous, and evanescent or persistent, is not a reliable character for differentiation of the different forms. But when all the characters are taken into consideration as a whole, the forms of the two groups above mentioned differ more from one another within the same group than between the two groups in other characters such as the size of ascospore, the length of appendages, etc. The writer is thus inclined to the opinion that the Chinese forms of *Microsphaera* on *Quercus* so far studied had better be referred to *M. Alni* as emended by Salmon.

The mode of branching of *M. Alni* var. *dentatae* (Liou) Tai (Bull. Ch. Bot. Soc. **1**: 22. 1935) is somewhat similar to that of *M. Alni calocladophora* (Atk.) Salm. in that the main axis of the primary branches, not dividing dichotomously at the apex, often grows on and bears sets of opposite branches, but the former differs from the latter in the smaller ascospores, shorter appendages, and more numerous asci. This type of branching is occasionally seen in other forms of *Microsphaera* on *Quercus*.

Microsphaera Decaisneae Tai.

Although *M. Decaisneae* (Lingnan Sci. Jour. **18**: 459. 1939) is close to *M. Alni*, it is unique in the few appendages, the uniformly colored basal part of the appendage (one-third or one-half the length from the base) and the larger spores.

Microsphaera berberidicola Tai, sp. nov.

On *Berberis* sp., HONAN: Sunghsien, Oct. 1939, C. S. Wang, *Wang 507*, TYPE.

Amphigena, plerumque epiphylla; mycelio persistente vel subpersistente, effuso; peritheciis dense gregariis vel sparsis, 80–97 μ diametro, cellulis parietis exterioris 7–13 μ latis; appendicibus 6–11, diametro perithecii 1–2.5 longioribus, ramulis, 3–4-, rarius 5- vel 6-dichotomis, ramulis ultimis plerumque recurvatis; ascis 4–7, late ovatis, 50–60 × 34–40 μ, 4–6-sporis; sporidiis ellipsoideis, 18–20 × 10–11 μ.

Amphigenous, chiefly epiphyllous; mycelium persistent to subpersistent, effused or forming patches; perithecia densely gregarious or scattered, cells of the perithecial wall 7–13 μ wide, 80–97 μ in diameter; appendages 6–11, equaling to 2.5 times the diameter of the perithecium, usually slightly exceeding the diameter, 3–4-, rarely 5- or 6-dichotomously branched, flaccid when long, the primary branches usually much longer than those of other orders, divergent, the ultimate branchlets mostly recurved, 7–8 μ wide and thick-walled at base; asci broadly ovate, 50–60 × 34–40 μ, 4–7 in number, usually 5–6; spores 4–6, ellipsoid, 18–20 × 10–11 μ. (Fig. 3.)

The plant is very close to *M. divaricata* in the mode of branching of the appendage and in the number of the same, but differs in the much shorter appendages and larger asci. It is also distinct from *M. lonicerae* in the smaller number of appendages, different mode of branching, longer asci, and smaller spores.

Microsphaera Grossulariae (Wallr.) Lev. ?*M. Sophorae* Gandara. Mem. Acad. Cient. Mex. **26**: 234. 1908. *M. Bidentis* Tai, Lingnan Sci. Jour. **18**: 458. 1939.

Burrill first referred *M. Van-Bruntiana* Gerard (Ell. & Ev. N. Am. Pyren. 24. 1892) to *M. Grossulariae*. This was followed by Salmon in his monograph on the Erysiphaceae (Mem. Torrey Club **9**: 157. 1900). Jaczewski (Karmanni opridielitel gribov. 2 Lieferung: Mehltaupilze 1927), however,

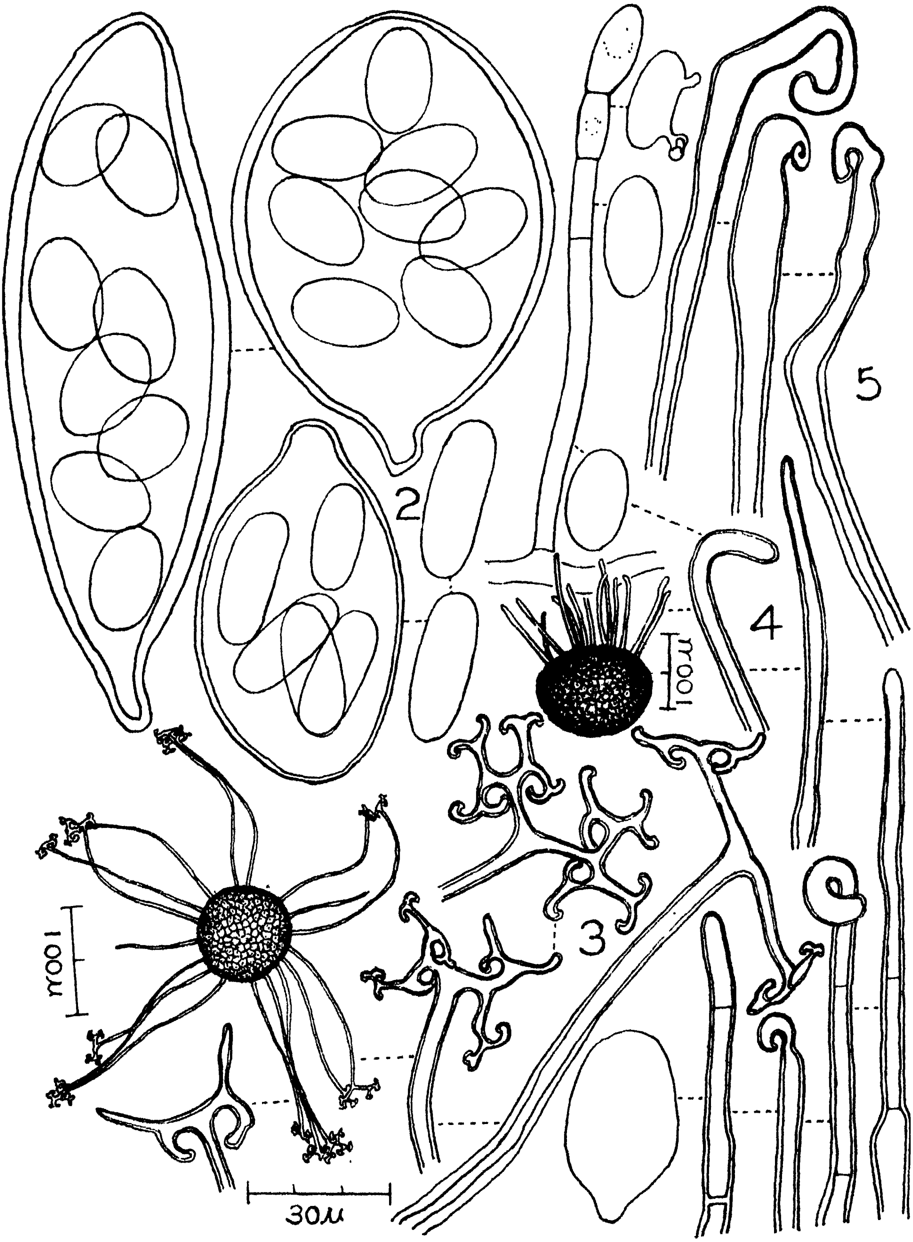

FIG. 1. *Sphaerotheca lanestris* (on *Quercus Delavayi*), 2 asci: the fusiform ascus becoming subglobose after absorbing enough water. FIG. 2. *Erysiphe Polygoni* var. *Epimedii*, 1 ascus and 2 ascospores. FIG. 3. *Microsphaera berberidicola*, 1 perithecium and 4 appendages, showing the mode of branching. FIG. 4. *Uncinula Acalyphae*, 1 perithecium, 4 appendages, 1 ascus; conidiophore and 3 conidia. FIG. 5. *Uncinula Verniciferae* (on *Chionanthus retusa*), 3 appendages.

considered them as distinct species. A careful comparison of the collections listed below of *Microsphaera* on *Bidens*, *Berberis*, *Caragana* and *Sambucus* led the writer to the conclusion that they all should be referred to *M. Grossulariae*. He is not sure whether *M. Sophorae* should be considered a synonym of the former, but the forms on *Caragana* and *Berberis* from North China which have referred to *M. Sophorae* (Bull. Ch. Bot. Soc. **2**: 23. 1936), do not differ essentially from *M. Grossulariae*.

The present writer has also studied collections of the forms of *Microsphaera* on *Berberis* and *Sambucus* from Japan. The collections no. 18 and no. 594 ex Herbarium Faculty of Agriculture, Hokkaido Imperial University, on *Berberis amurensis* and *B. vulgaris* respectively, originally labelled as "*Microsphaera Berberidis*," are identical with *M. Grossulariae*. Another collection from Japan on *Berberis Thunbergii*, also labelled as "*M. Berberidis*" is evidently to be referred to *M. divaricata*, since the primary branches are long and divergent and the tips of the ultimate branchlets all recurved.

Specimens examined: On *Sambucus chinensis* (not *Bidens* sp.), SZECHUAN: Kwanhsien, *Wei 2170*. On *S. japonica* KIANGSU: Nanking, *Shen 288*. On *S.* sp., JAPAN, Nov. 1927, *V. M. Chu*. On *Berberis amurensis*, CHAHAR: Shiaowutaishan, Aug. 20, 1934, *L. Shih*. On *B. Poiretti*, CHAHAR: Shiaowutaishan, Aug. 20, 1934, *L. Shih*. On *Caragana chamlagu*, HOPEI: Peiping, Sept. 12, 1934, *C. C. Cheo*. On *Berberis amurensis*, JAPAN: Sapporo, Oct. 3, 1925, *Y. Homma* (no. 18 ex Herbarium Faculty Agr. Hokkaido Imp. Univ.). On *Berberis vulgaris*, JAPAN: Sapporo, Sept. 8, 1921, *Y. Homma* (no. 594 ex Herbarium Faculty Agr. Hokkaido Imp. Univ.). On *B. Thumbergii*, JAPAN: Bot. Gard. Koishikawa, Tokyo, Nov. 29, 1904, *S. Kusano*.

MICROSPHAERA BLASTI Tai.

In a previous publication (Lingnan Sci. Jour. **18**: 458. 1939) the host plant of *Microsphaera Blasti* was given as *Blastus pauciflorus*. This has recently been found to be incorrect; it is *Lindera megaphylla*. Although *M. Blasti* is very close to *M. Benzoinis* (Bull. Ch. Bot. Soc. **1**: 23. 1935) and on a host of the same genus as the latter, yet the former is distinct in the more numerous and much longer appendages, fewer and smaller asci, fewer spores in each ascus, and the different mode of branching of its appendages.

M. Blasti: Appendages 7–15, usually about 10, rarely 2 or 4; 1–2, rarely 2.5 times the diameter of the perithecium, usually 1.5 times; 112–287 μ long, 7.8–8.5(11) μ wide at base; branching lax and irregular, the tips of the ultimate branchlets not all recurved. Asci 3–4, rarely 5 or 6; 42–57 × 30–41 μ; 2–4-spored, usually 3-spored. (Fig. 7.)

M. Benzoinis: Appendages 3–7, usually 4–5, rarely 2 or 11; shorter than or slightly exceeding the diameter of the perithecium, usually shorter; 57–86(100) μ long, 7–8.5 μ wide at base; branching close and regular, the ultimate branchlets all distinctly recurved. Asci 4–6, rarely 8; 46–71 × 31–51(56) μ; 3–5-spored, usually 4- rarely 2-spored. (Fig. 8.)

Microsphaera Robiniae Tai, sp. nov.

On *Robinia pseudoacacia*, KANSU: Tiensuei, Oct. 10, 1943, W. L. Hsian, *Hsian 197*, TYPE.

Amphigena, plerumque epiphylla; mycelio persistente, effuso; peritheciis dense gregariis, 119–146 μ diametro, cellulis parietis exterioris 10–15 μ latis; appendicibus 9–25, diametro perithecii 1–2 longioribus, flexuosis vel geniculatis, membrana ad basim crassi, hyalinis, saepe brunneolis, 1-septatis, ramulis 3–5 dichotomis, ramulis ultimis non recurvatis; ascis 6–13, ovatis vel ovato-oblongis, brevissime stipitatis, 64–73 × 29–36 μ, 4–7-sporis; sporidiis ovoideis, 17–20 × 11–13 μ.

The branching of the appendages is rather close; primary branches are usually longer than those of other orders, sometimes divergent. This plant shows affinity with *M. Euphorbiae*, but differs in the much shorter appendages, rather close-branching, and the longer asci. It is distinct from *M. Alni* var. *ludens* in the smaller number of appendages, ovate or ovate-oblong asci, and the never recurved ultimate branchlets. It is very close to *M. Umbilici* Kom., but differs in the more numerous and flexuous-contorted or angularly bent appendages and much shorter spores. (Fig. 6.)

UNCINULA CLINTONII Peck.

On *Celtis sinensis*, YUNNAN: Kunming, *4117*; Luliang, *7653*; Kaiyuan, *1128*. On *Firmiana simplex*, KWEICHOW: Meitang, C. U. Path. Herb. No. 648. On *Paulownia tomentosa*, SZECHUAN: Chingtan, *8190*.

The form on *Paulownia tomentosa* has the same characters as the others except that the appendages are often abruptly flexuous.

UNCINULA KENJIANA Homma.

On *Ulmus pumila*, HONAN: Sunghsien, *Wang 1293*.

Amphigenous; mycelium evanescent; perithecia subgregarious to scattered; cells of the perithecial wall 10–13 μ wide, 71–90 μ in diameter; appendages 7–14, ¾ to slightly ,exceeding the diameter of the perithecium, 5.7–6.4 μ wide at base, asperulate up to the apex, enlarged and coiled twice at the apex, thin-walled throughout, hyaline; asci 3–5, broadly ovate or subglobose, 43–57 × 34–47 μ; spores 2, ovoid, 34–37 × 20–23 μ.

UNCINULA DELAVAYI Pat.

On *Cedrela sinensis*, YUNNAN: Kunming, *4118*, *4119*, *5242*, *5243*, *7656*.

Amphigenous, chiefly hypophyllous; mycelium evanescent; perithecia subgregarious, 98–151 μ in diameter; cells of the perithecial wall 8.6–16 μ wide; appendages 6–12, rarely 4 or 15, shorter than (⅔), equaling, or slightly exceeding (1⅓) the diameter of the perithecium, short and long on the same perithecium, straight or usually slightly curved, somewhat undulating or geniculate, closely uncinate and wider towards the apex, 7–8.5 μ wide at the base, thin-walled above, thick-walled at the base, smooth; asci 4–10, ovate or ellipsoid, shortly stalked or not, 60–74 × 21–44 μ; spores 6–8, rarely only 5, ovate or ovate-oblong, 20–24 × 10–13 μ (commonly 20 × 11 μ).

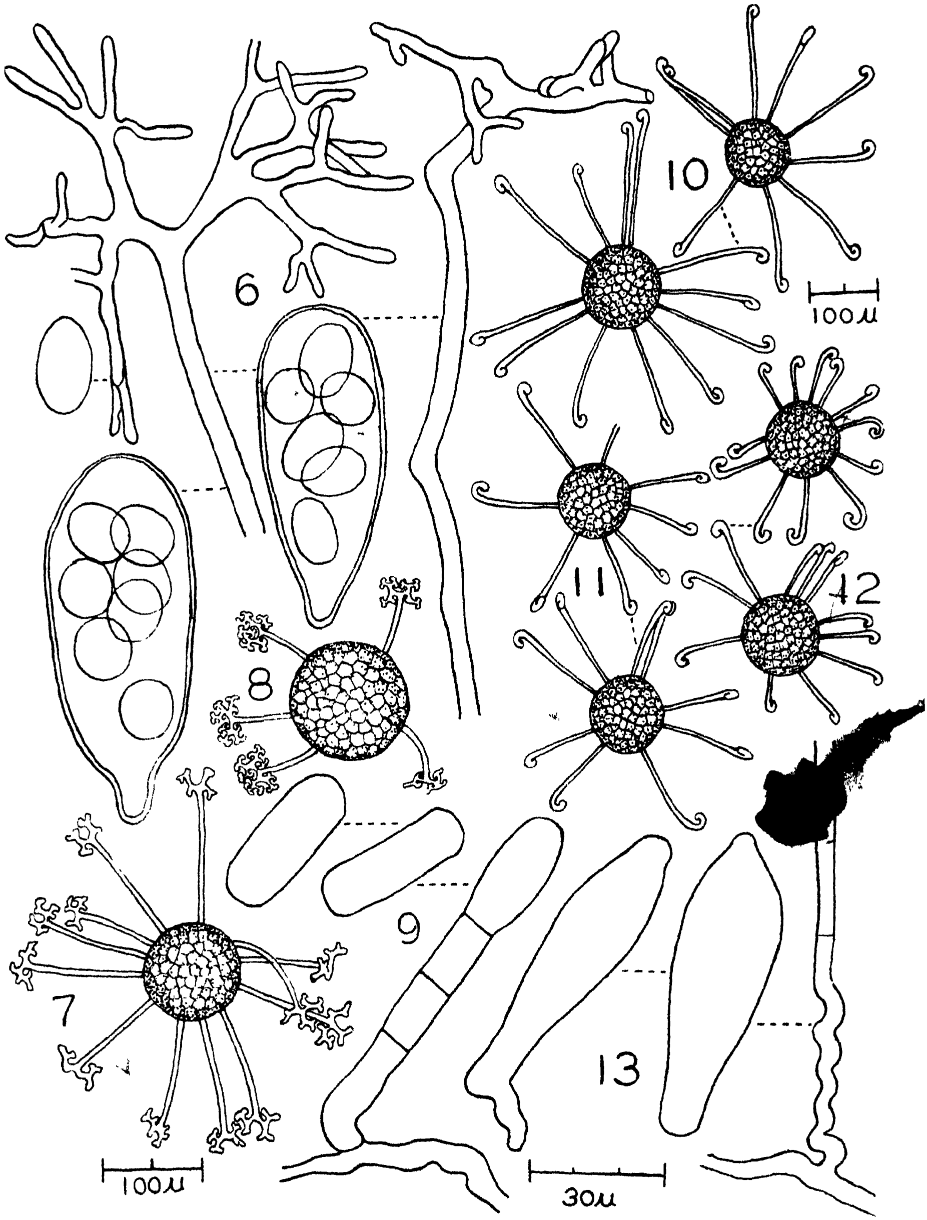

FIG. 6. *Microsphaera Robiniae*, 2 appendages, 2 asci and 1 ascospore. FIG. 7. *Microsphaera Blasti*, 1 perithecium. FIG. 8. *Microsphaera Benzoinis*, 1 perithecium. FIG. 9. *Uncinula yunnanensis*, conidiophore and 2 conidia. FIG. 10. *Uncinula Delavayi* var. *Cedrelae*, 2 perithecia. FIG. 11. *Uncinula Delavayi*, 2 perithecia (collection no. 5243) collected in 1939. FIG. 12. *Uncinula Delavayi*, 2 perithécia (collection no. 7656) collected in 1941. FIG. 13. *Uncinulopsis polychaeta* (on *Pueraria yunnanensis*), part of condiophore showing the spirally twisted basal part, and 2 conidia.

According to Salmon the appendages of *U. Delavayi* are "usually shorter than the diameter of the perithecium, rarely slightly exceeding it" (Mem. Torrey Club **9**: 118. 1900). The collections nos. 4118, 4119, 5242 and 5243 were made in 1939, no. 7656 in 1941 in the same locality. These two gatherings differ, however, in the length of the appendage and the size of the perithecium. The appendages of the 1939 collections are mostly equal to or slightly longer than the diameter of the perithecium, rarely shorter (92–181 µ long), and the perithecia are 98–132 µ in diameter; whereas the appendages of the 1941 collection are mostly shorter than the diameter of the perithecium (71–146 µ long) and the perithecia 100–151 µ in diameter. These differences seem to be due to the effect of different climatic conditions in the two years, for the fall of 1941 was much drier than that of 1939. (Figs. 11, 12.)

In 1936 *Uncinula Cedrelae* on the same host plant collected in North China was described by the writer as new (Bull. Ch. Bot. Soc. **2**: 20. 1936) on the basis of its longer appendages, larger perithecia and spores. The type specimen of *U. Cedrelae* has been examined again and compared with the Yunnan collection. It has been found that there is some difference between them: the appendages of *U. Cedrelae* are from equaling to 2⅓ times the diameter of the perithecium, never shorter (114–310 µ long); the perithecia and ascospores are larger. But in view of the observations made at Kunming as above mentioned on the effect of climatic conditions it seems best to make *U. Cedrelae* only a variety of *U. Delavayi*, and its variety *nodulosae* is also hereby changed to *U. Delavayi* var. **nodulosae** Tai, comb. nov.

UNCINULA DELAVAYI var. **Cedrelae** Tai, comb. nov. *U. Cedrelae* Tai, Bull. Ch. Bot. Soc. **2**: 20. 1936.

On *Cedrela sinensis*, HOPEI: Sanfangshan, Oct. 20, 1934, *L. Shih 1086*. (Fig. 10.)

UNCINULA MIYABEI (Salm.) Sacc. & Syd.

On *Cudrania tricuspidata*, YUNNAN: Kunming, *6886*; Chengkung, *7958*.

Amphigenous; mycelium persistent, effused or forming patches; perithecia gregarious to scattered, 94–111 µ in diameter; appendages 8–20, shorter than or usually 1–1.5 times the diameter of the perithecium, geniculate or flexuous, slightly enlarged toward the apex, thin-walled above, thick-walled at the base and rough, sometimes up to the apex, simply uncinate or loosely helicoid, hyaline; asci 3–7, broadly ovate to subglobose, 42–48 × 30–33 µ, not or very shortly stalked; spores 4–6, rarely 5, ellipsoid or oblong, 19–25 × 11–13 µ.

UNCINULA SALICIS (DC.) Winter. *U. mandshurica* Miura, Flora Manch. & E. Mongolia **3**, Fungi. 1930.

On *Populus Simonii*, HONAN: Sunghsien, *Wang 485a*. On *P.* sp., YUNNAN: Chichushan, *Tali 4130*. On *Salix* sp., SHENSI: Nanwutaishan, Sian, *8491*. On *S. Wallichiana*, YUNNAN: Kunming, *4120*.

This species seems to be very variable in the size of the perithecium and the number of the appendage. The Chinese forms usually have smaller perithecia (about 91–144 µ in diameter) and fewer appendages (about 23–60, sometimes only 18–37). Occasionally, however, forms with comparatively larger perithecia or more numerous appendages have been encountered. For instance, the perithecia of the collection no. 4130 and *Wang 485a* are 114–171 µ and 112–169 µ in diameter respectively. The fungus of the collection no. 4130 has 32 to 80 appendages, usually above 40, rarely only 24, and the Shensi plant 76 to 101. And in certain Chinese forms such as the latter there are only 6 to 8 asci in each perithecium.

Uncinula mandshurica Miura differs from *U. Salicis* mainly in the larger perithecium. In view of the fact that the size of the perithecium is very variable it seems proper to make *U. mandshurica* a synonym of *U. Salicis*.

UNCINULA SEPTATA Salmon. *U. curvispora* Hara, Mycologia **11**: 80. 1917. *Uncinulella curvispora* Hara, Parasitic Fungi of Japan 133. 1936.

On *Quercus Fabri*, HUNAN: Changsha, *4079*.

The writer studied authentic specimens of *Uncinula curvispora* from Japan (on *Fagus japonica*, Kawanyemura, Japan, August 1920, *K. Hara*) and has failed to find it distinct from *U. septata*. In 1917 Hara proposed a new genus, *Asterothecia*, to accommodate the fungus on *Fagus* because the perithecia turn over on their heads at maturity like those of *Phyllactinia Corylea*. In 1936 he changed the genus name to *Uncinulella* putting emphasis this time on the radially arranged cells of the perithecial wall. This kind of structure has been found by the present writer also in *Typhulochaeta* and *Uncinula Koelreuteriae*. Hara's genus is untenable.

UNCINULA SENGOKUI Salmon.

On *Celastrus articulatus*, FUKIEN: Shaowu, *Loh 19,861*.

The occurrence of this species in China was first reported by Miura from Liaoning on *Celastrus articulatus*. It has been collected again on the same host in the province of Fukien by Prof. Loh who has kindly sent the specimens to the writer for study. The characters of the fungus are as follows: amphigenous; mycelium evanescent to subpersistent, effuse or forming patches; perithecia gregarious to scattered, depressed-globose, 106–162 µ in diameter, mostly 119–125 µ; cells of the perithecial wall 7–14 µ wide; appendages 11–30, shorter than, equaling, or slightly exceeding (¼ to 1⅓) the diameter of the perithecium, short and long on the same perithecium (89–157 µ long, 7–8.5 µ wide at base), thick-walled below, straight or mostly curved, not or slightly enlarged upward, rarely flexuous at lower part, equatorially inserted; asci 9–13, broadly ovate or subglobose, very shortly stalked, 43–47 × 30–36 µ; spores 4–6, ellipsoid, 17–23 × 9–11 µ.

UNCINULA SINENSIS Tai & Wei.

On *Sophora japonica*, HONAN: Sunghsien, *Wang 580*. On ?"*Mallotus*" sp., KWEICHOW: Meitan, C. U. Path. Herb. No. 466.

The Meitan plant agrees closely with *U. sinensis* except that the asci are larger and the mycelium is persistent and dense: epiphyllous; mycelium persistent, dense, effused or forming patches; perithecia gregarious to scattered, cells of the perithecial wall 11–14 μ wide, 111–157 μ in diameter; appendages 9–28, shorter than (⅜), equaling, or 1.5 times the diameter of the perithecium, slightly enlarged above but narrowed at the apex, thin-walled, slightly thicker and asperulate at the base, 6–7 μ wide at the base, somewhat undulating; asci 5–8, ovoid to broadly ovate, 63–77 × 40–49 μ, shortly stalked; spores 4–6, usually 5, ellipsoid or oblong, 26–27 × 13–16 μ.

U. sinensis seems to have a wide range of hosts; it has been reported on *Acer*, *Sophora*, and *Rhus*.

UNCINULA VERNICIFERAE P. Henn.

On *Chionanthus retusa* (Oleaceae), YUNNAN: Kunming, *7763*. On *Cotinus coggyria*, HONAN: Chengpin, *Wang 255*.

The appendages of the plant on *Chionanthus retusa* are mostly enlarged at the upper one-third or one-half but always with narrowed apices. In the typical *U. Verniciferae* the appendages are usually not enlarged, but gradually narrowed upward from the lower two-thirds; some with enlarged middle part or upper one-third, however, also occur. The fungus on *Chionanthus* is considered a form of *U. Verniciferae*: epiphyllous, rarely amphigenous; mycelium persistent, thick, effused; perithecia gregarious or densely gregarious to scattered; cells of the perithecial wall 11–19 μ wide, 86–134 μ in diameter; appendages 11–23, rarely only 9, shorter than or usually equaling to 1.5 times the diameter of the perithecium (85–167 μ long), short and long on the same perithecium, enlarged upward, the broadest part 8.5–11 μ wide, 6–7 μ wide at the base, narrowed at the apex, loosely uncinate or helicoid, thin-walled above, thick-walled and asperulate at lower half, not or 1-septate at the base, the basal cell occasionally brown in color, straight or slightly curved, sometimes flexuous or geniculate; asci 4–6, rarely 3 or 9, broadly ovate or subglobose, 49–57 × 33–42 μ, not or shortly stalked, 6–8, rarely 5-spored; spores ellipsoid or ellipsoid-oblong, 17–20 × 8.5–11 μ. (Fig. 5.)

Uncinula carpinicola Hara was originally described as a variety of *U. geniculata*, the description of which was translated and published in 1917 by Tanaka (Mycologia **11**: 80. 1917). In 1927 Hara raised his new variety to specific rank, and redescribed the fungus as follows (Hara, Diseases of Trees [in Japanese], p. 195. 1927): amphigenous; mycelium thin, effused; perithecia gregarious or scattered, depressed-globose, averaging 100 μ in diameter; cells of the perithecial wall 7–15 μ wide; appendages usually 15–17, slender, thin-walled, colorless, 2–4 times the diameter of the perithecium, geniculate at the middle, narrowed at the apex and helicoid; asci 5–10, obovate or elliptic, 40–45 × 30–35 μ; spores 5–8, elliptic, ovate, or subglobose, 18–25 × 10–12 μ. In 1936 the present writer referred to *U. carpinicola* a species of *Uncinula* collected on *Carpinus Turczaninovii* by the late Mr. L. Shih in North China (Bull. Ch. Bot. Soc. **2**: 19. 1936). That plant, however, differs from *U. carpinicola* in the more numerous and shorter appendages (19–49, usually 30; 1–1¼ times the diameter of the perithecium against 16–20, usually 15–17, 2–4 times the diameter of the perithecium in *U. carpinicola*) and the larger perithecium and asci. It accords rather closely with the fungus on *Chionanthus* and is here also considered as a form of *U. Verniciferae*. *U. carpinicola*, being very close to the former, might prove to be identical on further study.

UNCINULA YUNNANENSIS Tai.

The conidial stage of *U. yunnanensis* has been observed to be as follows: amphigenous; mycelium persistent, forming patches; conidiophores 3-celled, curved at the basal part, 26–40 × 7 μ; conidia solitary, oblong or cylindrical, 30–33 × 11–13 μ. (Fig. 9.)

This species is very close to *U. Ehretiae* except that the perithecium is much smaller. In the original diagnosis of the latter it was not clearly indicated whether the appendages are thin-walled and enlarged near the apex. Wei (Nank. Jour. **11**: 107. 1942) reported a form of *U. Ehretiae* on *Bischofia trifoliata* from Szechuan the perithecium of which is about the same size as that of the typical plant. The appendages of the Szechuan fungus are, however, slender at their apex, and thick-walled at the base. If this be the case in the typical *U. Ehretiae*, then the Yunnan plant should remain a distinct species, as its appendages are always enlarged near the apex and thin-walled throughout. *U. yunnanensis* is tentatively kept separate from *U. Ehretiae* until the type of the latter is studied again.

Keissler (Symb. Sin. **2**: 21. 1937) suggested that *U. Ehretiae* might be identical with *U. aspera* of South Africa. The latter, however, differs from *U. Ehretiae* in the more numerous and much longer appendages.

Uncinula Acalyphae Tai, sp. nov.

On *Acalypha brachystachys*, YUNNAN: Shishan, Kunming, November 1938, *F. L. Tai 4153*, TYPE. *4152*, *4155*, *5293*, *5294*, *7603* and *8328*; SZECHUAN: Chengtu, *Ling 131*.

Amphigena; mycelio persistente effuso; peritheciis gregariis, 94–144 μ diametro; cellulis parietis exterioris 7–14 μ latis; appendicibus 24–50, rarius 8 vel 14, diametro perithecii 0.5–1 longis, membrana crassi, non vel 3-septatis, obscure brunneis, ad apicem non vel rare uncinatis; ascis 7–11, anguste vel late ovatis, 39–47 × 20–24 μ, immaturis.

Amphigenous; mycelium persistent, dense, effused; perithecia gregarious, depressed-globose; cells of the perithecial wall 7–14 μ wide, 94–144 μ in diameter; appendages 24–50, usually over 20, rarely only 8 or 14, on the upper half of the perithecium, 0.5 to equaling the diameter of the perithecium, straight or slightly flexuous, thick-walled up to the apex, not or 3-septate, dark brown, paler above, uniform in width, 4–6 μ wide, sometimes slightly tapering toward the apex, straight or slightly curved and blunt at the apex, rarely uncinate or helicoid; asci 7–11, ovate, 39–47 × 20–24 μ, immature. Conidiophore long and slender, 1–4-celled, the basal cell 4–6 times longer than the other cells, 46–113 μ up to 243 μ long, 4.3–7.0 μ wide; conidia solitary, ovoid or ellipsoid, 16–30 × 10–16 μ (21 × 11 μ), with granular contents. (Fig. 4.)

Ascospores are not delimited on all the specimens so far collected even as late as in December nor on overwintered leaves. This species has appendages similar to those of *U. septata* but it has much smaller perithecia and its appendages are rarely uncinate.

UNCINULA NECATOR (Schw.) Burr.

On *Vitis vinifera*, YUNNAN: Kunming, *4099*.

Only the conidial stage was collected: amphigenous, mycelium persistent, dense, effused or forming patches; conidiophores 1–3 celled, 74–143 × 7–8.5 μ; conidia solitary, oblong or ellipsoid, 29–39 × 13–18 μ.

Since 1935 many new species of *Uncinula* have been described from China. In the key to Chinese species of *Uncinula* in a previous publication (Bull. Ch. Bot. Soc. 1: 28. 1935), *U. Aceris* and *U. Tulasnei* were wrongly placed in the section with thin-walled appendages. That key is hereby corrected and revised to include new species published since them.

KEY TO CHINESE SPECIES OF UNCINULA

1. Appendages colored 2
Appendages colorless or only colored at base 5

2. Appendages colored throughout the entire length, narrowed toward apex. *U. simulans* Salm.
Appendages colored for only half of their length . . . 3

3. Appendages crowded on the upper half of the perithecium . . . 4
Appendages not so; perithecia 70–128 μ in diam. . . . *U. necator* (Schw.) Burr.

4. Perithecia 175–201 μ in diameter; appendages uncinate at their apex. *U. septata* Salm.
Perithecia 94–144 μ in diameter; appendages rarely uncinate at their apex. *U. Acalyphae* Tai.

5. Asci 2–3 spored 6
Asci 8 or 4–8 spored 7

6. Perithecia 85–115 μ in diameter; appendages thick-walled at base, close uncinate or helicoid at apex . . . *U. clandestina* Schroet.
Perithecia 71–93 μ in diameter; appendages thin-walled throughout, uniformly coiled twice at apex . . . *U. Kenjiana* Homma.

7. Asci 8 spored 8
Asci 4–8 spored 12

8. Appendages some or all bifid or multifid; spores 8, rarely 6 . . . 9
Appendages not so; spores regularly 8 11

9. Mycelium densely compacted; appendages mostly simple . . . *U. Tulasnei* Fuckel.
Mycelium not densely compacted; all or most of the appendages bifid or multifid 10

10. Appendages 1–2 dichotomously branched; perithecia 120–225 μ in diameter; asci 4–12, 70–95 × 45–55 μ . . . *U. Aceris* (DC.) Sacc.
Appendages 2–3 dichotomously branched; perianth 232–313 μ in diameter; asci 14–34, 97–109 × 43–52 μ . . . *U. polyfida* Wei.

11. Appendages thin-walled throughout; perithecia 76–105 μ in diameter. *U. Fraxini* Miyabe.
Appendages thick-walled at base;[5] perithecia 213–312 μ in diameter. *U. nankinensis* Tai.

12. Appendages stout, 7–8 μ wide at the base 13
Appendages narrower at the base 18

13. Appendages thin-walled, 11–32; perithecia 92–143 μ in diameter. *U. sinensis* Tai et Wei.
Appendages thick-walled at base 14

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[5] When the wall is more than twice the thickness of the wall above.

14. Appendages with colored bulbous base .... *U. bulbosa* (Tai et Wei) Tai.
Appendages not so 15
15. Appendages 4–12, enlarged upward 16
Appendages 20–36, not or slightly enlarged upward .... *U. Sengokui* Salm.
16. Appendages regularly nodulose .... *U. Delavayi* var. *nodulosae* Tai.
Appendages not or occasionally nodulose 17
17. Appendages shorter than or equaling the diameter of the perithecium, rarely slightly exceeding; perithecium smaller .... *U. Delavayi* Pat.
Appendages 1–2⅓ times the diameter of the perithecium; perithecium larger. *U. Delavayi* var. *Cedrelae* Tai.
18. Appendages thin-walled 19
Appendages thick-walled at base 22
19. Perithecia 85–175 μ in diameter; appendages 10–150 20
Perithecia 70–90 μ in diameter; appendages 2–9 .... *U. yunnanensis* Tai.
20. Appendages 10–27, narrowed upward; asci 3–5 .... *U. australiana* MacAlpine.
Appendages 30–150, slightly enlarged upward; asci 6–14 21
21. Appendages swollen in places; asci 6–8, 47–54 × 31–35 μ. *U. Salicis-gracilistylae* Homma.
Appendages not swollen in places; asci 8–14, 55–80 × 30–40 μ. *U. Salicis* (DC.) Winter.
22. Appendages 4–8, shorter than the diameter of the perithecium .... *U. Ehretiae* Keissl.
Appendages 6–48, equaling to 2 times the diameter of the perithecium 23
23. Appendages narrowed at apex 24
Appendages enlarged upward or slightly so, not narrowed at apex 25
24. Asci 6–8 spored, rarely 5; spores 15–29 × 8.5–19 μ .... *U. Verniciferae* P. Henn.
Asci 4–5 spored, sometimes 3 or 6; spores 27–35 × 14–19 μ .... *U. Mori* Miyake.
25. Appendages more or less angularly bent, not swollen at apex 26
Appendages straight or often more or less undulating, not angularly bent, swollen at apex .... *U. Clintonii* Peck.
26. Appendages 6–13; asci 50–71 × 38–56 μ .... *U. Miyabei* var. *Aleuritis* Wei.
Appendages 10–22(48); asci 48–59 × 32–41 μ .... *U. Miyabei* (Salm.) Sacc. et Syd.

Typhulochaeta Koelreuteriae (Miyake) Tai, comb. nov. *Uncinula Koelreuteriae* Miyake, Bot. Mag. Tokyo **27**: 39. 1913. *Erysiphe Koelreuteriae* (Miyake) Tai, Bull. Ch. Bot. Soc. **2**: 16. 1936.

On *Koelreuteria bipinnata*, HONAN: Chengpin, *Wang 194*.

In the classification of the Erysiphaceae all the students of the group up to the present day, following Léveillé, separate the genera on the basis of the characters of the appendage and the number of asci. On the discovery of endophytic mycelium in *Leveillula taurica* by Salmon in 1906, and in *Uncinulopsis subspiralis* by Sawada in 1916, it is clear that the characters of the appendage alone are not dependable for differentiating genera. Besides the true appendages, there occur in certain species (*Phyllactinia Corylea* and *Uncinula bulbosa*) gelatinous penicillate cells on the upper part of the perithecium; whereas in other species (*Typhulochaeta japonica* and *Uncinula Koelreuteriae*) only the penicillate cells are present. If the characters of these penicillate cells are constant and are correlated with other constant morphological characters, there is no reason why they should not be used as criteria for distinguishing genera. Ito and Hara established the genus *Typhulochaeta* (Bot. Mag. Tokyo **29**: 20. 1915) mainly on the gelatinous clavate penicillate cells of their *T. japonica.* Miyake, on the other hand, referred the powdery mildew collected by him at Nankow, China, on *Koelreuteria bipinnata* to the genus *Uncinula* as *U. Koelreuteriae* because some of the penicillate cells are uncinate at their apex. After a careful study of the latter fungus at Peiping, the present writer found that the gelatinous cells occurring on the upper half of the perithecium are similar to the penicillate cells of *Phyllactinia Corylea,* but not comparable in any way to the true non-gelatinous appendages of *Uncinula.* He therefore referred this species to the genus *Erysiphe,* since perithecia with obsolete appendages are not rare in that genus. Clements and Shear (Genera of Fungi 249. 1931) and Wei (Nank. Jour. **11**: 3. 1942) did the same thing by transferring *Typhulochaeta japonica* to *Erysiphe.*

T. japonica was recently collected in this country at *Kwanhsien,* Szechuan (Nank. Jour. **11**: 3. 1942). Through the kindness of Dr. C. T. Wei the writer had the opportunity to make a careful study of that species, and found that it shows close affinity with the fungus on *Koelreuteria.* Both of them lack the true appendages and have a perithecial wall of small cells, 4–11 μ wide. The cells are mostly oblong in shape and are more or less radiately arranged with the smallest cells at the apex and the base, and the largest at the equator. In none of the species of *Erysiphe* has this kind of arrangement of the cells of the perithecial ever been observed nor has the presence of penicillate cells been reported. Although the perithecial wall of *Uncinula septata* also consists of radiately arranged cells, yet the regular uncinate appendages are present. In view of these it seems that for the present the genus *Typhulochaeta* had better be maintained and that the proper disposal of the fungus on *Koelreuteria* is to transfer it to that genus.

TYPHULOCHAETA JAPONICA Ito et Hara. *Erysiphe japonica* (Ito et Hara) Clements & Shear, Gen. Fungi 249. 1931. *Erysiphe japonica* (Ito et Hara) Wei, Nank. Jour. **11**:,3. 1942.

On *Quercus Baroni,*[6] SZECHUAN: Kwanhsien, *Wei 2183.* On *Q. alienta,* SZECHUAN: Kwanhsien, S.P.A.I.I. *122.* On *Q.* sp.,[6] SZECHUAN: Kwanhsien, *Wei 2199.*

The writer found that the spore number of this species is usually 8, rarely 6 or 7. The apical septate and light brown appendages as mentioned by Wei at the top of the perithecium were not observed by the writer.

UNCINULOPSIS POLYCHAETA (B. & C.) Homma emend. Wei. *Uncinula polychaeta* (B. & C.) Ellis, Jour. Myc. **2**: 43. 1886. *Uncinula Shiraiana* P. Hennings, Engl. Jahrb. **29**: 148. 1900. *Phyllactinia Corylea* var. *subspiralis* Salmon, Ann. Myc. **3**: 501. 1905. *Phyllactinia subspiralis* Sawada, Agr. Exp. Sta. Sp. Bull. **9**, 1914. *Uncinulopsis Shiraiana* (P. Henn.) Hara,

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[6] These host plants are identified in Wei's paper as *Castanopsis* sp.

Jour. Plant Protection **7** (5). 1920. *Phyllactinia subspiralis* (Salm.) Blumer, Beitr. Kryptogamenfl. Schweiz **7**: 399. 1933.

On *Celtis sinensis*, YUNNAN: Kunming, *4124, 7830;* Hualing, *4123;* I-Liang, *4127;* Tachwang, *4126;* Mengtze, *4125;* Chengkiang, *4129;* KWANGSI: I-shan, C. U. Path. Herb. No. 96. On *Campylotropis polyantha*, YUNNAN: Kunming, *7552*. On *Pueraria yunnanensis*, YUNNAN: Kunming, *7260, 6887.*

The fungus on *Celtis* was described as new by P. Hennings in 1900 under the name of *Uncinula Shiraiana*. It is very close to *U. polychaeta* except that the asci of the latter are usually 2-spored. Salmon (Bull. Torrey Club **27**: 439. 1900) considered *U. Shiraiana* as a synonym of the latter, stating that although the asci of Chinese and Japanese specimens are usually 3-spored, sometimes 2- or 4- or very rarely 5-spored, the occurrence of 3 or 4 spores in the ascus in some American specimens has also been reported by Tracy and Galloway.

A conidial stage of powdery mildew on *Dalbergia Sissoo* with spirally twisted basal part of the conidiophore was discovered in India in 1905 and described by Salmon as a new variety of *Phyllactinia Corylea*, var. *subspiralis*. Basing their disposition on conidial stage only, Sawada in 1914 and Blumer in 1933 raised this variety to specific rank. In 1916 Sawada discovered endophytic mycelium in the fungus on *Celtis* and also its conidial stage of the *subspiralis* type. He then created a new genus, *Uncinulopsis*, to accommodate that fungus and changed *Phyllactinia subspiralis* to *Uncinulopsis subspiralis*. This name was subsequently again changed to *U. Shiraiana* by Hara since P. Hennings' name is the earliest applied to the perithecial stage of the said fungus. Homma (Jour. Fac. Agr. Hokkaido Imp. Univ. **38**: 183–461. 1937) transferred *Uncinula polychaeta* to the genus *Uncinulopsis*, but considered it distinct from *U. Shiraiana*. Wei (Nank. Jour. **11**: 10. 1942), being unaware of this new combination, again transferred *Uncinula polychaeta* to *Uncinulopsis*, including in it the fungus on *Celtis*.

Conidial stage of powdery mildews of the *subspiralis* type on *Pueraria yunnanensis* and *Campylotropis polyantha* has been collected by the writer at Kunming. These host plants have been under observation for two years but no perithecia have ever been produced on them, although the fungus on *Celtis* nearby produces perithecia in great abundance. Then the writer undertook to compare the conidial stage on *Pueraria* and *Campylotropis* with that on *Celtis* to see whether or not they are different. The fungus on *Pueraria* and *Campylotropis* shows the following characters: hypophyllous; mycelium persistent, effused or forming patches; conidiophore 2–4-celled, loosely spirally twisted at the lower part, hyaline, 127–183 × 6–8.6 μ; conidia various in shape, clavate, subcylindrical, fusiform, 51–81 × 16–20(26) μ (broadest part). The conidiophore of the fungus on *Celtis* is 2–5-celled and measures 120–217 × 7 μ; the conidia 57–75 × 14–20 μ. From these measurements it is clear that morphologically the conidial stage of the powdery mildew on *Celtis* does not differ from that of the fungus on *Pueraria* and *Campylotropis*. The fact that the latter does not produce perithecia is due to unknown factors. There are not lacking examples such as *Erysiphe Cichoracearum* which rarely produces perithecia on Cucurbitaceae. Although measurements of conidia and conidiophore were not given by Salmon in his diagnosis of the variety *subspiralis*, yet according to the scale of his illustrations the conidia and conidiophores are about of the same size as those on *Celtis*, *Pueraria*, and *Campylotropis*. (Fig. 13.)

Leveillula taurica (Lev.) Arn.

On *Reinwardtia trigyne*, Yunnan: Kunming, *7224, 7960*. On *Tropaeolum majus*, Yunnan: Kunming, *8492*.

Hypophyllous; mycelium persistent, forming definite patches; conidiophores 3–5-celled, 7–9 μ wide, branched; conidia obclavate to subcylindrical, hyaline, 49–90 × 16–18 μ. The conidia of these forms are slightly longer and broader than those usually recorded for this species.

Phyllactinia Corylea (Pers.) Karst.

On *Ailanthus altissima*, Hunan: Yolushan, Changsha, *4081*. On *Alangium platanifolium*, Szechuan: Chengtu, *7773*. On *Alnus nepalensis*, Yunnan: Kunming, *7225*. On *A. cremastogyne*, Szechuan: Chengtu, *5302*. On *Broussonetia* sp., Hunan: Hwanhsien, *4086*. On *Caesalpinia sepiaria*, Yunnan: Kunming, *8203*. On *Castanea mollissima*, Yunnan: Chengkung, *4093*; Kweichow: Meitan, *7825*; Kwangtung: Canton, *4092*. On *Cedrela sinensis*, Yunnan: Kunming, *7212*. On *Diospyrus Kaki*, Yunnan: Süanwei, *8025*; Kunming, *5256*. On *D. lotus*, Yunnan: Kunming, *7239, 8077*; Chengkiang, *4094*. On *Lindera* sp., Hunan: Hengshan, *4080*. On *Morus alba*, Yunnan: Kunming, *7191, 4088*; Kutsing, *8013*; Chengkiang, *4089*; Kweichow: Meitan, *7823, 7938*; Hunan: Yolushan, Changsha, *4087*; Kwangtung: Canton, *4090*. On *M. australis*, Yunnan: Kunming, *5259, 8076*. On *Pterocarya stenoptera*, Kweichow: Meitan, *7939*; Szechuan: Chengtu, *5306*. On *Principia utilis*, Yunnan: Kunming, *8153*. On *Pyrus pasha*, Yunnan: Kunming, *4085, 7573*. On *P. serotina*, Yunnan: Kunming, *7253*. On *Quercus alienta*, Kweichow: Meitan, *7937*; Hunan: Hangshan, *4084*.

Phyllactinia Salmonii Blumer.

On *Paulownia tomentosa*, Szechuan: Chingtan, Dec. 6, 1939, *C. T. Wei*. On *Actinidia chinensis*, Hunan: Hengshan, *4083*. On *A. lanata*, Kwangsi: Sankianghsien, *Cheo 2926*. On *A.* sp., Kwangsi: Sankianghsien, *Cheo 2934*.

Hypophyllous or rarely amphigenous; mycelium evanescent to subpersistent, effused or forming patches; perithecia subgregarious to scattered; cells of the perithecial wall obscure, 312–393 μ in diameter; appendages 11–26, slightly exceeding to 1.5 times the diameter of the perithecium, 362–518 μ long, brownish, subhyaline or hyaline; asci 20–24, ovate, ellipsoid, or oblong, with a short stalk, 93–114 × 31–48 μ, 2-spored; spores broadly ovate, 40–46 × 21–24 μ.

The diagnosis of *Phyllactinia Salmonii* as published by Blumer was based on the fungus on *Paulownia imperialis* from Japan. In regard to the size of perithecium this form is quite isolated from the others of *Phyllactinia Corylea*, the diameter of the perithecium of which reaches only to 288 μ. In addition, the large size of this plant is correlated with a large number of appendages. The form on species of *Actinidia* collected in this country also shows the same characters as that on *Paulownia*. In the writer's opinion *Phyllactinia Salmonii* is a good species.

Phyllactinia imperialis Miyabe is given as the name for the fungus on *Paulownia imperialis* in Hara's "Parasitic Fungi of Japan" (p. 138. 1936); when and where that name was published are not indicated in that book; as far as the writer is aware that name has not been effectively published.

OIDIUM Link.

On *Althaea rosea*, YUNNAN: Kunming, *8493*.

Amphigenous, chiefly epiphyllous; mycelium subpersistent, forming patches; conidiophores perpendicular to the hyphae, 3-celled, 8.3–10 μ wide; conidia elliptic, oblong or cylindrical, 31–43 × 13–18 μ.

On *Artemisia Sieveriana*, YUNNAN: Kunming, *4100*.

On *Berberis Wilsonae*, YUNNAN: Kunming, *4104*.

Amphigenous, mainly epiphyllous. mycelium persistent, effused; conidiophores perpendicular to the hyphae, 1–5-celled, usually 3-celled, 90–113 × 7–9 μ; conidia solitary, sometimes in chains, oblong or cylindrical, 26–49 × 10–15 μ.

On *Castanea mollissima*, YUNNAN: Kunming, *6358*.

On *Cucurbita* sp., YUNNAN: Kunming, *7831*.

On *Fraxinus chinensis*, YUNNAN: Kunming, *7691*, *7952*.

On *Lagerstroemia indica*, YUNNAN: Kunming, *4106*, *7772*, *7907*, *7951*.

Amphigenous and caulicolous; mycelium thick, effused, doing great damage to young shoots; conidiophores 2–6-celled, commonly 3, 69–89 × 7–10 μ; conidia solitary, oblong or cylindrical, 24–39 × 11–16 μ (*Uncinula australiana?*).

On *Leucas ciliata*, YUNNAN: Kunming, *7928*.

On *Ligustrum lucidum*, YUNNAN: Kunming, *4108*, *5280*.

On *Lycium chinense*, YUNNAN: Kunming, *5278*.

On *Lycopersicum esculentum*, YUNNAN: Kunming, *7950*.

Conidiophores 3-celled, 41–71 × 7–8.6 μ; conidia ovoid or ovate-oblong, 31–41 × 14–16 μ.

On *Malva verticillata*, YUNNAN: Kunming, *4104*, *5279*.

On *Medicago sativa*, YUNNAN: Tachwang, *1140*.

Amphigenous; mycelium persistent, effused; conidiophores perpendicular to the hyphae, 68–88 × 5.7–7.1 μ; conidia oblong or cylindrical, 27–34 × 10–14 μ (*Erysiphe Polygoni?*).

On *Mirabilis Jalapa*, YUNNAN: Kunming, *4107*, *5285*, *5289*.

On *Momordica charantia*, YUNNAN: Tali, *4148*.

On *Oxalis corniculata*, YUNNAN: Kunming, *4105*.

On *Panax pseudo-ginseng*, YUNNAN: Wenshan, *8494*.

Amphigenous; mycelium persistent, forming definite patches; conidiophores 3-celled, 50–87 × 6.4–10 μ; conidia solitary, oblong, 33–37 × 13–17 μ.

On *Quercus* sp., YUNNAN: Kunming, *7833*.

On *Robinia pseudo-acacia*, YUNNAN: Kunming, *4102*.

On *Rubia oncotrica*, YUNNAN: Kunming, *7954*.

On *Siegsbeckia orientalis*, YUNNAN: Kunming, *7949*.

On *Sonchus oleracea*, YUNNAN: Kunming, *7955*.

On *Sophora japonica*, YUNNAN: Kunming, *8495*.

Epiphyllous; mycelium persistent, effused, web-like, radiating from centers; conidiophores 3-celled, 69–74 × 8.6–10 μ; conidia solitary ellipsoid, 26–34 × 14–20 μ.

On *Sophora viciifolia*, YUNNAN: Kunming, *5251, 5252, 8032*.

Amphigenous, mainly epiphyllous; mycelium dense and effused; conidiophore 3-celled, 33–84 × 7.1–8.6 μ; conidia solitary, ellipsoid-oblong to subcylindrical, 31–38 × 13–14 μ.

On *Urena lobata*, YUNNAN: Chengkiang, *4097*.

On *Urtica angustifolia* var. *abbreviata*, YUNNAN: Kunming, *7953*.

On *Vicia unijuga*, YUNNAN: Kunming, *5248, 5249*.

On *Vigna sinensis*, YUNNAN: Kunming, *8496*.

Amphigenous, mainly epiphyllous; mycelium persistent, forming patches; conidiophore 2–3-celled, 70–80 × 13–14 μ; conidia in chains, ovoid with fibrosin bodies, 31–46 × 19–21 μ.

SUMMARY

A careful comparative study has been made of available collections of most of the species of the Erysiphaceae so far reported from China, and it has been found that it seems advisable to keep the collective species: ***Erysiphe Cichoracearum*, *E. Polygoni***, and ***Microsphaera Alni*** as emended by Salmon. Climatic conditions have been found to affect morphological characters in *Uncinula Delavayi* at Kunming. As a result of this study several species have been reduced to synonymy. *Uncinula Koelreuteriae* has been transferred to the genus *Typhulochaeta*. One variety of ***Erysiphe***, two species of ***Microsphaera*** and one variety and one species of ***Uncinula*** are described as new.

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BULLETIN OF THE TORREY BOTANICAL CLUB
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NOTEWORTHY PLANTS OF TEXAS—V. ADDITIONAL PSORALEAE

B. C. THARP AND FRED A. BARKLEY

One species and two varieties of *Psoralidium* and one species of *Parosela* section *Pogonatherae* occurring in Texas seem to be undescribed.

Psoralidium Youngiae[1] Tharp & Barkley, sp. nov. Herba perennis; caulibus simplicibus subter, ramosis supra, 5–9 dm. altis, canescentibus, strigosis; foliis digitatis, 3–5-foliolatis stipulis lanceolatis, acuminatis, glabris nisi longis-ciliolatis, glandulosis, 1 mm. longis, persistentibus; petiolis 1–2 cm. longis, canescentibus; foliolis 1–3 cm. longis, 3–8 mm. latis, latis-oblanceolatis, glandulosis-punctatis, subglabris nisi ad midvenos supra, subtus canescentibus; pedunculis 4–6 cm. longis; racemis 4–6 cm. longis, floribus multis; bracteis deltoideis-lanceolatis, acuminatis, 1.5–3 mm. longis, glandulosis, sparse strigosis, dense ciliolatis; pedicelis 1–2 mm. longis, longe-hirsutis; calyce 2 mm. longo, glanduloso; lobis subaequalibus, deltoideis, acutis, dense ciliolatis; corolla caerulea, circa 6 mm. longa; vexilla suborbiculari; leguminibus ovatis, proboscide abbreviato.

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[1] Mary Sophie Young, daughter of Emma Adams Sainer and Charles Huntington Young, was born in September, 1872, at Glendale, Ohio, the youngest child and only daughter in a family of eight children of an Episcopal minister. She was reared at Glendale, Washington, and Gambin, Ohio. After graduation from Harcourt Place Seminary at Gambin, Ohio, in 1891, she attended Wellesley College until 1895 when she received her A.B. degree. From 1895 to 1897 she was an instructor in Louis Academy at Sullivan, Missouri; from 1897 to 1898 at Dundee (Illinois) High School; from 1898 to 1906 at Grafton Hall, Fond-du-Lac, Wisconsin; and at Waterman Hall, Sycamore, Illinois, during 1907–1908. In 1900 she began graduate work at the University of Chicago during the summer, and in 1906–1907 spent the year there, receiving the S.M. degree. From 1908 to 1910 she continued graduate study there, doing work on the morphology of the Podocarpineae which was published in the Botanical Gazette (**50**: 81–100. 1910). She received the Ph.D. degree in 1910. In the fall of 1910 she came to the University of Texas as a tutor, became an instructor in 1911 and continued in that capacity until her death on March 5, 1919.

A fine teacher and of generous disposition she soon became one of the inspiring teachers at the University of Texas. Her thoughtfulness and understanding of students was outstanding so that she is still affectionately remembered by them as an example of what the relationship between student and instructor should be.

Coming to the University of Texas when she did she found knowledge of the flora of west Texas very fragmentary, so that the end of the spring semester usually found her alighting from a train in west Texas, accompanied by a student or not, buying a spring wagon, a team of burros, and supplies, and heading into the inaccessible portions of that area, to reappear just before the opening of the fall semester loaded down with plants from the botanically unknown cañons, plains, and mountains. In her short career in the state she established the Herbarium of the University of Texas as a going concern, and left a contribution of exceptionally valuable specimens, duplicates of which were distributed to several of the larger American herbaria. She enigmatically distributed specimens as having been collected by "M. S. Young," and was pleased at having acknowledgements addressed to her as "Dear Sir."

She kept interesting daily accounts of her several collecting trips, which are deposited in the botanical library of the University of Texas. These embody graphic and often humorous accounts of the conditions and experiences encountered in her field work. In a comparatively short career in Texas few people have so inspired a younger generation of workers, or have left so much in the way of valuable permanent scientific data.—University of Texas Herbarium Biographical Sketch VIII. B. C. Tharp & Fred A. Barkley.

A perennial with creeping rootstock; stem simple below, branched above 4–9 dm. high, silvery-canescent, strigose, striate, not glandular-dotted; leaves digitately 5-foliolate below, 3-foliolate above; stipules lanceolate, acuminate, glabrous except long-ciliolate, glandular, 1 mm. long, persistent; petioles 1–2 cm. long, striate, canescent; leaflets 1–3 cm. long, 3–8 mm. broad, obovate to broadly oblanceolate, rounded to subacute, glandular-dotted on both surfaces, subglabrous except on the midnerve above, mucro minute, obscured by a tuft of hairs; petiolules about 1 mm. long, densely canescent; peduncles 4–6 cm. long, canescent; racemes 4–6 cm. long, many-flowered; flowers 2–4 at each node; bracts deltoid-lanceolate, acuminate, 1.5–3 mm. long, glandular, sparsely strigose, densely ciliolate with very long hairs; pedicels 1–2 mm. long, long hirsute; calyx 2 mm. long, dark colored, glandular, subglabrous and strigose-canescent in lines; lobes subequal, deltoid, acute, shorter than the tube, densely ciliolate; corolla blue, about 6 mm. long; banner suborbicular; pod ovoid, glabrous, glandular dotted, with short erect beak.

TYPE: Midfield, Texas, April 7, 1939 (II), *B. C. Tharp s.n.* in the University of Texas Herbarium.

This species is closely allied to *P. floribundum* (Nutt.) Rydb., *P. tenuiflorum* (Pursh) Rydb. and *P. obtusilobum* (T. & G.) Rydb. in general aspect. It is more densely canescent, the inflorescence more compact, the ciliation of the calyx-lobes is shorter and denser, the pedicel is shorter than the calyx, and the bracts are shorter and broader.

Besides the typical variety, *Psoralidium linearifolium* (T. & G.) Rydb. is represented in Texas by two varieties:

Psoralidium linearifolium var. **palodurensis** Tharp & Barkley, var. nov. Varietas speciei similis exceptis bracteis lanceolatis, acutis, calycis lobis subacuminatis, floribus majoribus et longius pubescentibus.

Perennial; 4–8 dm. high, striate, with long slender branches; branches sparingly glandular-dotted, sparingly strigose with long white hairs; leaves short-petioled; leaflets 1–3, very short petiolulate, glabrous above, strigose below, glandular-dotted above and below, 3–6 cm. long, 2–3.5 mm. broad; flowers in loose racemes, pedicels slender, 1–1.5 cm. long, bracts lanceolate, acute, glandular-dotted, strigose, 3–5 mm. long, petals 10 mm. long; calyx 6 mm. long, 2.5 mm. broad, strigose, glandular-punctate, calyx lobes densely long-ciliolate, lanceolate, subacuminate.

TYPE: Palo Duro Canyon, Texas, June 15, 1929, *B. C. Tharp 5767* in the University of Texas Herbarium.

Psoralidium linearifolium var. **texensis** Tharp & Barkley, var. nov. Varietas speciei similis exceptis bracteis ovatis, cordatis, calyce obliquo et glandulosissimo, calycis lobis subacutis.

Perennial, 4–8 dm. high, striate, with long slender branches; branches sparingly glandular dotted, strigose; leaves subsessile; leaflets 1–3, very short petiolulate, glabrous above, strigose below, glandular-punctate above and below, 2–5 cm. long, 2–4.5 mm. broad; flowers in loose racemes, pedicels slender, 6–9 mm. long; bracts deltoid-ovate, cordate, acute, glandular-dotted, strigose, 1–2 mm. long; petals 8 mm. long; calyx 3.5 mm. long, 2 mm. broad, sparsely strigose, densely glandular-punctate, calyx lobes subacute, glabrous except margin densely short-ciliolate.

TYPE: Sherman Lake, Grayson County, Texas, June 15, 1939, *B. C. Tharp s.n.* in the University of Texas Herbarium.

This is the common variety in Texas, although the typical variety enters the state in the northeast corner.

Parosela Walkerae[2] Tharp & Barkley, sp. nov. Herba perennis; radicibus ligneis; caudice ligneo, brevi; caulibus 1–2 dm. altis, gracilibus, sparse minute pubescentibus, sparse glandulosis; foliis 5–25 mm. longis; foliolis 3–11, oblanceolatis, 3–7 mm. longis, glabris; pedunculis circa 2 cm. longa; spicis laxis, 4–5 cm. longis; bracteis late ovatis; longe acuminatis, subter conspicue glanduloso-punctatis, margine plus minusve scarioso; calycis tubo late turbinato, circa 2.5 mm. longo, sericeo; calycis lobis 2.5 mm. longis, subulatis, ad basim triangularibus; corolla purpurea.

A perennial, with a woody root and short caudex; stems 1–2 dm. high, slender, microscopically sparsely puberulent; sparsely glandular; leaves 0.5–2.5 cm. long; stipules subulate, 2 mm. long; rachis margined, glabrous, sparsely glandular-dotted; leaflets 3–11, oblanceolate, broadly cuneate at base, rounded at apex, 3–7 mm. long, glabrous, very sparingly glandular dotted; spikes lax, 4–5 cm. long; bracts broadly ovate, long-acuminate, conspicuously glandular-dotted on the back, somewhat scarious margined; calyx tube broadly turbinate, about 2.5 mm. long, silky-villous; lobes 2.5 mm. long, abruptly subulate from a triangular base; corolla deep purple; pod sparsely villous above, densely long villous on the margins.

TYPE: La Joya, Hildalgo County, February 2, 1942, *Mrs. E. J. Walker s.n.*, in the University of Texas Herbarium.

The inflorescence of *P. Walkerae* is lax and interrupted much as it is in *P. enneandra* (Nutt.) Britt. but the corolla is a deep purple. The habit, calyx and bract are most similar to that of *P. pogonathera* (A. Gray) Vail. The calyx-lobes are abruptly subulate and about the length of the calyx-tube as contrasted with the larger calyx of *P. pogonathera*, whose abruptly subulate calyx-lobes are from one and one-half times to twice as long as the tube. *P. lasianthera* (A. Gray) A. Heller has calyx-lobes broad at the base, gradually tapering to subulate tips, the lobes much shorter than the tube.

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[2] Thelma, daughter of Mr. & Mrs. E. D. Ratcliff, born at Kingman, Indiana, on December 20, 1908, married E. J. Walker on April 24, 1930. In 1909 moved to the Rio Grande Valley (Starr County, Texas) where she lived until she married except for the first four grades of school at McAllen. Her home is now at La Joya. Since 1933 she has collected many specimens of flowering plants which have gone into the S. M. Tracy Herbarium, The Gray Herbarium of Harvard University, and the University of Texas Herbarium. Her color portraits of native flowers show unusual skill in technical painting. She is eminently deserving of recognition for the many interesting plants and extensions of range which her collections in the Rio Grande Area have made available for study.—University of Texas Herbarium Biographical Sketch IX. B. C. Tharp & Fred A. Barkley.

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TYPES OF ANTHESIS IN HEMEROCALLIS AND THEIR HEREDITY IN F_1 HYBRIDS

A. B. STOUT

It has been recognized and discussed at some length (Stout 1933; 1934) that in species of *Hemerocallis* there are three main types of anthesis: (1) the diurnal or day-blooming, (2) the nocturnal or night-blooming, and (3) the extended blooming. For some time it has been evident to the writer that there are further distinctions in the periods of anthesis of the sets of flowers of daylilies and that special methods in the analysis, description and representation of the time-intervals of anthesis are desirable in respect to evaluations (a) of the antheses of the successive sets of flowers under different conditions of weather, (b) of the behavior that can be considered characteristic of species and hybrids, and (c) of the heredity of the different types of anthesis in hybridization. It is to be noted that this paper is primarily concerned with the nature and character of anthesis and not with the calendar dates or season when flowering occurs.

METHODS OF OBTAINING AND PRESENTING DATA

In daylilies an individual flower is open during only one period, in the condition known as anthesis. The many flowers of a plant mature in a rhythmic succession of groups or sets and the flowers of each set have antheses that are synchronous. One may obtain data for an entire set of flowers and speak of the collective antheses as the anthesis of the set. When two or more individuals, especially of a species or of a progeny of known parentage, are uniform in flower behavior, or nearly so, their synchronized antheses may be treated collectively as an anthesis of the entire group. Also the data for different antheses during an entire period of flowering may be combined in ways that provide an evaluation of the fundamental character of what may be called the anthesis of an individual, a clone, a group of sister hybrids, or a population of a species.

In collecting the data here reported it was the aim to make observations on each individual or each group of plants at intervals of not more than three hours during the entire period of the anthesis of a single set of flowers and to obtain such data from a number of different sets during the season of flowering. To facilitate the collection of the data during the night several scapes were cut in the late afternoon of plants growing in the experimental garden at The New York Botanical Garden. These were put in pails with the stems in water and transported by auto to the author's home where they were placed on an open veranda. Under careful handling the flowers of such scapes closed or opened with normal regularity for observations between 6:00 P.M. of that evening and 6:00 A.M. of the next morning. Usually the flower behavior was then observed for the same plants in the experimental plots not later than 9:00 A.M. Flowers, in considerable number, of each set were labeled with marking tags of different colors and numbers in a way that made certain the identification and the records of successive sets of flowers. This procedure was especially necessary when there was overlap of sets, interpolation of a set, or a delay in the development and anthesis of a set of flowers. Unless otherwise stated all of the data presented in this paper including that of the figures were collected during 1941.

Anthograms.[1] The diagrams shown in the figures accompanying this article were devised by the writer to present graphically the essential features of the different types of antheses in *Hemerocallis.*

The data for the anthesis of any single set of flowers produced by an individual or by two or more individuals that are reasonably uniform may be used in constructing a diagram which may be called an *s-anthogram.* Such diagrams may be oriented in a chart according to the clock hours of daylight and darkness. Then the base line of an s-anthogram indicates the time-interval between the beginning of anthesis and its conclusion, and the upper line of the diagram indicates the time-interval during which the flowers were fully open. In figure 1 the entire body of the s-anthograms is blocked solidly in black, but in figures 2 and 3 the s-anthograms are much flattened.

The data for any number of antheses of an individual plant or of a number of plants which have the same or very similar flowering behavior may be combined and represented in a composite diagram here designated a *c-anthogram.* Such a diagram (see figures 1 and 4) indicates the extremes in the time of opening and closing of all sets of flowers that were observed on an individual plant, on a group of ramets of a clone, or on a number of individuals of the same species or progeny. The four points from left to right in the base line indicate the earliest (*1*) and the latest (*2*) inception of anthesis; and the earliest (*3*) and the latest time (*4*) of the completion of anthesis for all the sets of flowers observed. The four points in the upper line of the c-anthogram indicate the earliest time (*a*) and the latest time (*b*) of full anthesis; and the earliest time (*c*) and the latest time (*d*) when flowers began to close. The body of a c-anthogram between points *b* and *c* is blocked-in in black and this section indicates the time-interval during which flowers were widely open on every day of the observations. Thus the *b–c* interval indicated by the section in black is common to all sets observed and it is an important value for comparisons. The numbers and letters applied to the time-points of e-anthograms are indicated for two e-anthograms of figure 1 and for one e-anthogram of figure 4.

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[1] The term anthogram was suggested to the writer by Dr. Harold W. Rickett.

The two kinds of anthograms as here constructed are distinctly different in appearance (fig. 1). They present rather graphically the values for those features of anthesis that are characteristic of species, of groups of individuals of a hybrid progeny, or of members of a clone. When they are coordinated according to the hours of the day, as in figures 1–4, evaluations and comparisons of the character of the various anthesis are simplified. It is to be noted that the anthograms which are oriented according to hours of a day in the vertical columns of these tables are not for the same calendar day and also that the two or three s-anthograms in the same level are not necessarily for successive days.

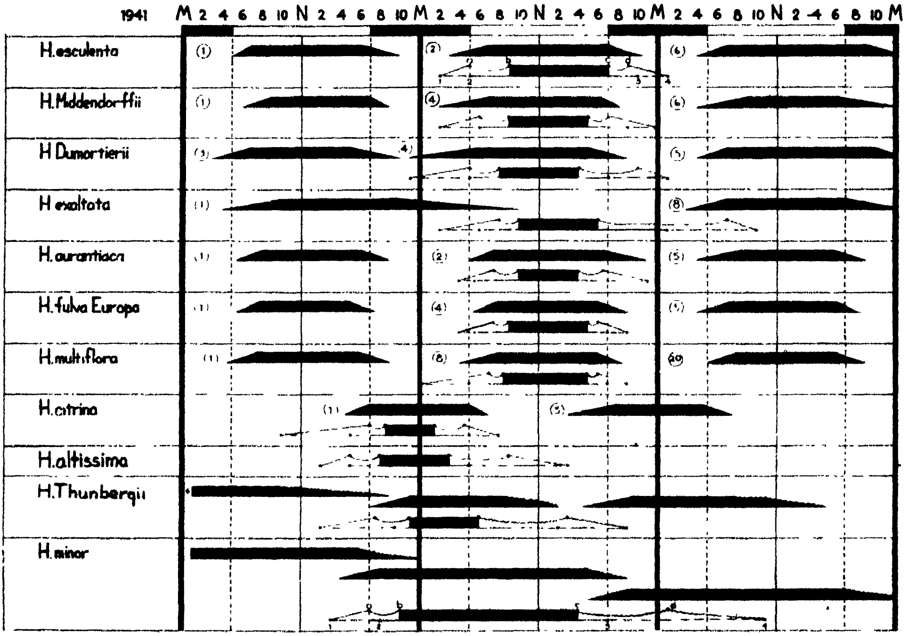

FIG. 1. Typical s-anthograms (entirely in black) and e-anthograms (with 8 time-points as indicated under *H. esculenta* and *H. minor*) for 11 species of *Hemerocallis*.

DAY-BLOOMING SPECIES

The first seven sections in figure 1 are for daylilies that have diurnal anthesis. Of each of these except the clones of "*H. aurantiaca*" and *H. fulva* clone *Europa* there was available for observations a considerable number of ramets of different clones, or of seedlings, or of both seedlings and clones. Yet there was remarkable uniformity within the numbers of each group with respect to the flower behavior of any anthesis.

In figure 1 the two or three s-anthograms that are given for each species are representative but usually they do not indicate the extremes of the variations in anthesis that were observed and which are indicated in the c-anthogram.

Members of the species *H. esculenta, H. Middendorffii,* and *H. Dumortierii,* of the day-blooming species, flower early in spring. *H. exaltata, H. aurantiaca,* and *H. fulva* clone *Europa* flower in midsummer. Members of the species *H. multiflora* collectively flower in late summer and autumn. Hence the diurnal habit is well distributed over the entire growing season.

Survey of Diurnal Anthesis. The anthograms presented in figure 1 for the seven day-blooming daylilies, and especially the c-anthograms, show that the end-points of all the *common intervals* (*b–c*) fall between 8:00 A.M. and 7:00 P.M. and that the mid-points in the antheses fall somewhat after 12:00 noon except for *H. Dumortierii.* There are definite and specific differences in various features of diurnal anthesis.

In the region about New York City *H. fulva* clone *Europa* blooms in midsummer and shows slight variation in *a–b, c–d,* and *1–2* and *3–4* time-points and intervals. The distinctive clonal name "Europa Daylily" was given (Stout 1929) to the clone that has long been grown in Europe, and to Linnaeus and many other botanists and gardeners it was the only plant of *H. fulva* which was known. Kerner and Oliver (1895) published a list of species which have ephemeral flowers that open once only for a part of a day. The period of anthesis for flowers of "*Hemerocallis fulva*" is given as 14 hours, the time of opening between 8:00 to 9:00 A.M. and the time of closing at 4:00 to 5:00 P.M. But in another table it is stated that at Upsala, Sweden, the flowers of *H. fulva* open at 5:00 A.M. and close at 7:00 to 8:00 P.M., while at Innsbruck, Austria, they open between 6:00 and 7:00 A.M. and close between 8:00 and 9:00 P.M. It is stated that in the famous floral clock constructed by Linnaeus plants of *H. fulva* were included for the closing hour of 7:00 to 8:00 P.M.

The Europa Daylily is widely grown in Europe and America over a rather wide range in latitude and variations are to be expected in respect to calendar dates of flowering and to responses of anthesis under different temperatures and periods of daylight. Dr. Hamilton P. Traub has reported to the author by letter during 1944 that at Salinas, California, the flowers of the Europa Daylily "last not only two days but several days due to the cold weather that slows up growth and senescence." At New York during thirty-three years of observation the writer has never observed in any flowers of this daylily the extension of an anthesis into the hours of a second period of daylight.

H. aurantiaca, also a clone, which blooms with the Europa Daylily has somewhat shorter anthesis, as shown by the value of *b–c,* but more variation in opening and closing (see values for *a–b, c–d,* and *3–4*).

The data for the group of seedlings of *H. exaltata*, also summer-flowering, show much irregularity in time of closing. Occasionally in cool and rainy weather the flowers remain widely open throughout the night following a rather normal day-blooming. The latest time-point for full opening (*d*) was 7:00 A.M.; and the earliest complete closing (*3*) was 1:00 P.M. Thus the anthesis of the plants of *H. exaltata* is definitely day-blooming in regard to the common period (*b–c*) but it is more extended into the hours of darkness than in any other of the day-blooming species that were studied.

The three species *H. esculenta*, *H. Middendorffii*, and *H. Dumortierii* flower early in spring, usually during May. These are quite alike in anthesis. *H. Dumortierii* is somewhat more variable in the intervals of opening and closing, but its common period of anthesis is more balanced in reference to mid-day.

The three s-anthograms for *H. multiflora* are for the original plants obtained from China and some 75 of their seedlings, and they are for the 1st, the 8th, and the 20th day of the observations. But no data were taken for the more delayed opening and closing that frequently occurs in plants of this species after the first week in September. Otherwise for this species the time-intervals of opening are more extended and irregular than are the intervals of closing.

For all the day-blooming species that were studied the common intervals *b–c* were definitely diurnal and in no case was there an overlap at any time of two sets of flowers that were fully open.

Other day-blooming species besides those reported above include *H. nana*, *H. Forrestii*, and *H. littorea*. Of the first two of these, there have been few plants and flowers for study. Of the so-called *H. littorea* there are numerous clonal propagations of a plant obtained from Japan and a considerable number of its selfed seedlings. The flowers of these are definitely day-blooming during warm sunny days throughout the earlier portion of the blooming period but during the cool weather of late September and October the anthesis is often delayed, extended, and irregular; and frequently all flowers of a set remain only partly open.

It may be noted that all the day-blooming daylilies discussed above have either clear orange or fulvous-red flower coloring. It may be noted, however, that *H. coreana* (Nakai 1932), which is described as yellow-flowered, is reported by Hara (1941) to have "yellow diurnal flowers."

THE NIGHT-BLOOMING SPECIES

Of the named species which have nocturnal anthesis only two are definitely known to the writer and data for these are presented in figure 1. Both have flowers that are pale yellow and odorous.

H. citrina. Of this species there were ramets obtained from Italy, which are believed to be divisions of the plant described as the type of this species, and also seedlings grown from seeds that were collected in the wild in China. In 1941 the combined period of bloom for these was from June 24 to July 30. Two rather typical s-anthograms are shown in figure 1 and the c-anthogram combines all of the observations made on the antheses of these plants in 1941. The *b–c* interval for these plants extended over about five hours of darkness with the median points near 11:00 P.M. In only two sets did the flowers start to open earlier than 3:00 P.M., and the earliest time-point for full opening was at 7:00 P.M. Certain of the unnamed wild night-blooming day-lilies which the writer has obtained from the Orient do not conform closely to the robust plants to which the name *H. citrina* was first given. Especially do some of these have smaller flowers and more narrow leaves. Hara has given two new specific names (*Hemerocallis yezoensis*, 1938; *H. vespertina*, 1941) to collections that had been classed as *H. citrina*, and he states that plants of *H. vespertina* are night-blooming.

H. altissima. Of the species named *H. altissima* (Stout 1943) the type and co-type plants and numerous of their seedlings have been studied. The collective blooming period of these much-branched plants has extended from the middle of July until late in October, but no data on the anthesis were collected after September 10. In the observations that were made the *b–c* interval for this rather large group was a duration of seven hours with its median point at 11:30 P.M. Hence the anthesis is definitely nocturnal in character. During autumn when there are often cool nights the flowers may remain widely open until 9:00 A.M. and on some days they are not fully closed until 3:00 P.M.

A comparison of the c-anthograms of these two night-blooming species shows a difference of two hours in the extent of the *b–c* interval; the time-points of opening are more extended in *H. citrina;* and the time-points of closing are more extended in *H. altissima.* But these contrasts may be due to the differences in the temperatures of summer and autumn. For both species the common interval (*b–c*) was completely nocturnal, and there was no overlap at any time of two sets of flowers that were fully open.

SPECIES WITH EXTENDED ANTHESIS

1. The Semi-Extended Anthesis of Hemerocallis Thunbergii. Of this species there were available for study ramets of the clone propagated under this name in England since 1867, a few of the seedlings derived from these by controlled pollination, and also plants of this type that were obtained directly from the Orient.

The c-anthogram compiled from a considerable number of s-anthograms and a large number of observations for a part of the day shows that the common interval for the widely open condition extended from 11:00 P.M.

to 6: 00 A.M.; hence this feature of anthesis is definitely nocturnal. But during the cooler days of midsummer the full anthesis of sets of flowers may continue until 3: 00 P.M. of the following period of daylight. The earliest hour for complete closing was 2: 00 P.M. and the latest was 8: 00 P.M. But during most of the interval of closing (*c–4*, from 6: 00 A.M. to 9: 00 P.M.) the flowers were often wilting and fading and more or less unsightly.

The flowers of these plants do not open early enough to make a good showing during the late afternoon. During the hours of the forenoon in hot weather they are sometimes fading and wilting. In the afternoon a set may be closed as early as 2: 00 P.M. and if the closing is later the flowers are usually unsightly. The c-anthogram for *H. Thunbergii* shows that the latest hour of full anthesis was 3: 00 P.M. and the earliest hour for this time-interval (*a*) was about 7: 30 A.M. Thus there was no overlap of two sets in full anthesis.

No data are given in figure 4 for the anthesis of F_1 hybrids which have plants of *H. Thunbergii* for a parent. In all of the progenies of these hybrids that were studied and also in progenies of intra-specific breeding there were variations of the anthesis of sister F_1 hybrids during a single day of as much as several hours in the time-points. It is considered that at least some of the plants of *H. Thunbergii* for which data are here shown are somewhat heterozygous in respect to the heredity of anthesis. There were, however, no appreciable variations in the anthesis on any one day among the plants included in this particular study.

The plants of *H. Thunbergii* which are included in this report have an anthesis that is chiefly nocturnal with an extension of the time-points of closing (*c–d* and *3–4*) into the following hours of sunlight. This extension is promoted by cool temperatures which, during the period of flowering, usually accompany rainy or cloudy weather.

Several collections of *Hemerocallis* obtained from the Orient are somewhat similar to the type of *H. Thunbergii* in the character of the flowers but are different in having taller and more branched scapes and differences in foliage. The species *Hemerocallis yezoensis* (Hara 1938) is described as more like *H. Thunbergii* than *H. citrina*, and as having flowers that are night-blooming but which remain open during the following forenoon.

2. **The More Extended Anthesis of H. minor.** Of this species there were studied ramets of several clones that have been cultivated in Europe and seedlings grown from their seeds. Since 1941 several collections of seeds from wild plants in Northern China have been grown which are to be included in *H. minor*. The entire normal period of first-flowering for this group especially studied in 1941 extended from May 1 to June 27. There is also a second-period of blooming by numerous plants which extends into the autumn, but special data on anthesis were not obtained for such flowers.

Observations were made on the anthesis of sixteen different sets during the period of first flowering. The s-anthograms or parts of them that are shown clearly indicate that an extended anthesis is normal for these plants. The time interval *1–3* was 28 hours and that of *2–3* was 23 hours, hence the shortest complete anthesis observed was somewhere between 23 and 28 hours. The common interval *b–c* was 18 hours and it extended from 10:00 P.M. until 4:00 P.M. of the following day. After 3:00 P.M. there was much overlap of two successive sets but it was only between 7:00 P.M. and 1:00 A.M. that both sets were ever widely open at the same time.

The time-intervals of the inception of anthesis of *H. minor* were definitely nocturnal and they show slight fluctuation. The anthesis is extended to as late as 1:00 A.M. of the next period of darkness, but there is much fluctuation in closing and often the flowers fade and wilt.

It may be noted that a scape of *H. minor* with an open flower and buds is illustrated in plate 18 of the Somoku-Dzusetsu (Iinuma 1874). A translation of the text supplied to the writer by Professor T. Maekawa states that "the flower begins to open after sunset and begins to close after sunrise and wilts in the forenoon. Therefore the people say 'Yuu-Suge' meaning Evening Daylily. Another name for this plant is 'Matsu-yoi-gusa' which means 'waiting-evening-herb.'" Other Japanese publications note that the flowers of this species are night-blooming with some extension into the following period of daylight.

A comparison of the anthesis of *H. minor* with that of *H. Thunbergii* may be made as follows. The antheses of these two species are very similar in being nocturnal in inception and somewhat similar in the range of variations in closing. There is considerable wilting and fading of the flowers of both. But the extension of anthesis is much greater in *H. minor* and more completely a combination of nocturnal and diurnal periods.

3. **The Much Extended and Sensitive Anthesis of H. flava.** The studies here reported are entirely for the ramets of a clone that has long been grown in Europe and America under the common name "Lemon Daylily." This clone is the historical type on which Linnaeus bestowed the name *Hemerocallis flava*, and he evidently knew no other yellow-flowered plant of *Hemerocallis*. Many live plants of yellow-flowered members of *Hemerocallis* have come directly to The New York Botanical Garden from the Orient and also seeds have come from which numerous seedlings have been grown to maturity. Also the writer has examined herbarium specimens of collections of wild plants of *Hemerocallis* at Edinburgh, London, and New York. Not one of all these plants or specimens can correctly be assigned to the Linnaean type of *H. flava*. For a discussion of this matter reference may be made to an earlier publication (Stout 1935). Of the other clones of daylilies in cultivation in Europe which the writer has seen only one is noticeably similar to

the Lemon Daylily. Its flowers are smaller, the foliage is more upright, and the capsules are different in size and shape. But in color of flowers, habits of the growth of foliage and of rhizomes, season of flowering, and flower behavior the two clones are very similar.

For the observations during the one flowering season in 1941, at least 100 well-grown clusters of this one clone of the Lemon Daylily were available at The New York Botanical Garden, in my own home garden, and in the gardens of three of my neighbors. Rather complete records were obtained, often with observations at one-hour intervals, for the entire antheses of 22 consecutive sets of flowers which opened between May 20 and June 8 inclusive. The entire period of flowering for the group of plants was from May 12 to June 14, but during the first week and the last week of flowering there were relatively few flowers open.

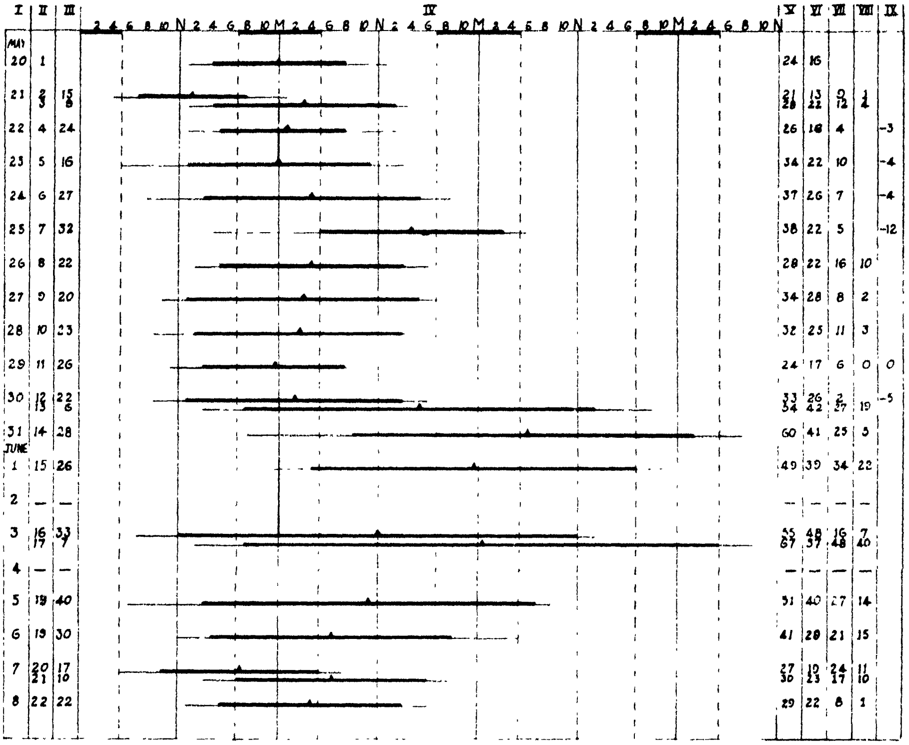

FIG. 2. Data and s-anthograms for 22 consecutive sets of flowers of the clone known as *Hemerocallis flava.*

In figure 2 the s-anthograms are more flattened than in figure 1. The intervals of full opening is represented by the heavier portion and the time-intervals of opening and closing are shown by narrow extensions. Each s-anthogram with its time-points is placed according to the hours of the day

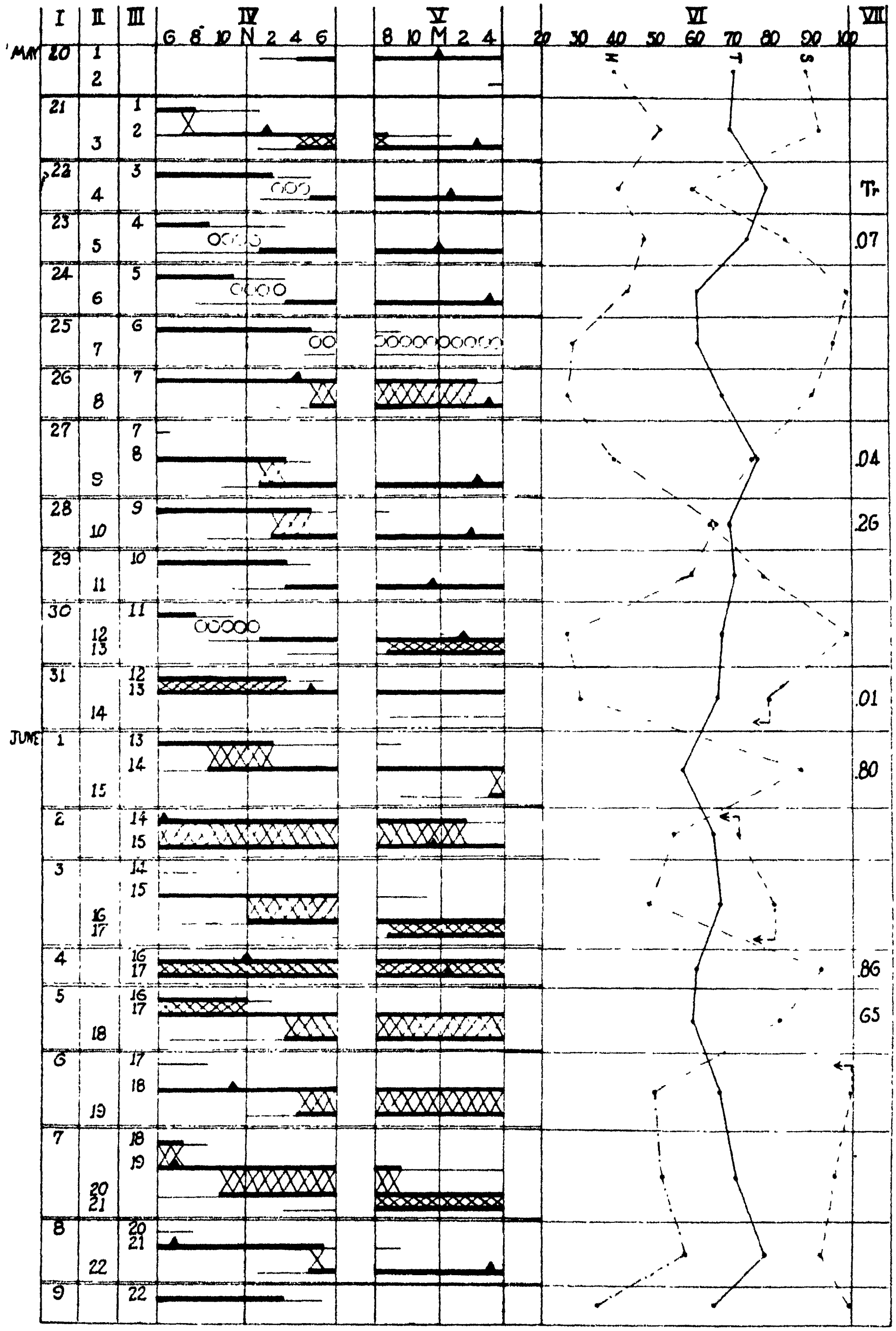

FIG. 3. Data for the antheses of flowers of *Hemerocallis flava*. Explanation in text.

and they are in succession from top to bottom according to the calendar dates (midnight to midnight) of the day when each anthesis was initiated. Each of the dates given in column I is for the day during which an anthesis began and in section IV the time-points of each set of flowers are placed according to hour and day. The section IV is extended to cover two and one-half days in order to include the most extended anthesis.

The different s-anthograms in figure 2 graphically indicate the differences in the intervals of anthesis and their position with respect to the hours of darkness and sunlight.

In the columns at each side of the section IV in figure 2 there are given the numerical values for important features of anthesis as follows: I, calendar dates when antheses began; II, number of each of the sets in succession; III, interval in hours between the inception of the antheses of two successive sets; IV, distribution of intervals of anthesis according to hours of daylight and darkness; V, time-intervals of entire anthesis; VI, time-intervals for the complete opening of each set; VII, time-interval of the overlap in the entire period of anthesis of each set with that of the previous one; VIII, time-interval of overlap of the full opening of each set with that of the previous one; and IX, time-intervals when no set was in full bloom.

In figure 3 the data for the antheses of the 22 sets of flowers of the clone *H. flava* are arranged in a manner that emphasizes certain of the values of the antheses. The representation of the character of the different antheses is coordinated in column IV for each successive period of daylight (5:00 A.M. to 7:00 P.M.) and in column V for the following period of darkness (7:00 P.M. to 5:00 A.M.). Thus the behavior of all sets in any stage of anthesis at any time of each day is indicated. In column I, there are calendar dates for the successive period of daylight; II lists the number of the one or more sets that started their antheses during each of the successive periods of 24 hours; column III indicates the number of each set whose anthesis continued from the previous 24-hour period; IV and V show the coordination of s-anthograms, and the overlap in the condition of full opening of two or more sets is shown by cross-hatching. Circles indicate the time-intervals during which no flowers were fully open.

In section VI there are graphs which indicate the mean temperature (T) in degrees of Fahrenheit, the percentage of relative humidity (H) at noon, and (S) the per cent of the possible sunlight. In column VII are records of the rainfall. These data were obtained from the Monthly Meterological Summaries of data at New York for May and June, 1941, prepared by the U. S. Department of Commerce, Weather Bureau.

Features of the antheses indicated in figures 2 and 3 will now be discussed.

Inception of Anthesis. This was decidedly diurnal; all of its time-points fell between 4:00 A.M. and 10:00 P.M., and 16 of the 22 were between 8:00

A.M. and 4:00 P. M. For 10 sets the inception was between 1:00 P.M. and 4:00 P.M. Even the interpolated sets (Nos. 3, 13, 17, 21) and the sets (Nos. 33 and 40) that followed a day during which no set started anthesis all had points of the inception of anthesis that fell within the range of those sets that were in regular sequence.

Time-Points of the Beginning of Full Anthesis. For 17 of the sets studied this time-point fell between noon and 8:00 P.M., inclusive. The time most typical for the inception of full anthesis was in the afternoon.

Extent of Antheses. The intervals of entire anthesis (start to finish) ranged from 21 to 67 hours with an average of 37 + (fig. 2, column V); the interval of complete opening varied from 13 to 57 hours with an average of 28 (fig. 2, column VI). The anthesis was definitely more extended than that of the plants which were studied of *H. minor*.

Molisch (1938) records that the longevity of flowers of *Hemerocallis flava* is 6 days. But at The New York Botanical Garden no anthesis of more than 72 hours (Stout 1933) has been observed on this daylily.

Disposition of Anthesis. As noted already, the inception of anthesis is definitely diurnal with its time-points most frequent in the afternoon. The most typical disposition of anthesis is that it continues throughout the night and well into the following hours of sunlight.

Overlap of Different Sets. The intervals of an overlap of sets that were widely open are indicated in figure 3 by cross-hatching while circles indicate the time when there were no flowers *widely* open. Values in hours for the overlap of a set with the previous set are given in figure 2; column VII for entire overlap; VIII for overlap of flowers fully open; and IX for no overlap of flowers that were fully open. There were 15 different periods when there was an overlap of two sets and the extent of these ranged from one to 40 hours. There was only one period of two hours when three sets were fully open together. Thus the conditions which give extension of sets with delay in completion of anthesis definitely inhibit and delay the development and anthesis of the next set of flowers.

In case of overlap the flowers of a new set are for a time paler in color than are the flowers of the older set (Stout 1933, 1934).

There was no time during which there were no flowers in some stage of opening, but there were five different periods of from 3 to 12 hours when there were no flowers fully open.

Interpolation. The interpolation of an extra set of flowers was observed. Of the sets 2 and 3 the latter may be regarded as an extra set for there was no omission of a set on either the previous day or on the following one. The same condition was seen for the sets 12 and 13 and for the sets 20 and 21.

Omission of a Set. But the two sets (16 and 17) which started anthesis close together on June 3 were preceded and followed by the only two *omissions* observed. But reference to figure 3 will show that on both these days there were two sets in extended and full anthesis. The time-interval between the inception of two successive sets may be extended to as much as 40 hours. Between the closing of a set and the start of opening of the next set after an omission there was always an overlap (see anthograms for 15, 16, and 17; and 17 and 18 in figure 3).

Influences of Temperature, Humidity and Sunlight. That the conditions just mentioned affect various features of anthesis is obvious and certain to one who observes anthesis in daylilies from day to day. It is to be recognized that these external influences operate to affect the internal processes of growth, differentiation, and development of flowers. In the daylilies that have branched inflorescences, as does the Lemon Daylily, most of the flowers are on secondary laterals which develop in bostryxes (Stout 1941) after the primary flowers have bloomed. There is much growth and development in each bostryx of the inflorescence after flowering begins. There will often be two or more flowers open on a scape at the same time but seldom in a single bostryx. Especially in the later part of the blooming period there will be omissions in the daily maturity of at least one flower of a scape. But the omission of an entire set during the season of heavy bloom, as was observed in *H. flava,* involves a synchronous and systemic condition in all scapes of the various ramets of a clone.

High temperatures, clear sunny days, and dry weather all combine to shorten the period of anthesis and to advance the inception into the hours of the forenoon. These conditions existed for a few days before May 20 and continued while sets 1 and 2 had antheses of 24 and 21 hours. Also an interpolated set (No. 3) occurred during this time. The first noticeably delayed set (No. 7) followed a drop in temperature.

On May 30 there was an interpolated set (No. 13) which had a much extended anthesis, as had the following two sets. On the 30th the temperature was rather high and it remained quite uniform but there was a decrease in sunlight and a rise in humidity. The day was hot, cloudy and "muggy."

The weather conditions which extend anthesis also check or delay the development of the next set of flowers. The anthesis of the interpolated set 13 was much extended over that of set 12 and the antheses of sets 14 and 15 which followed were both delayed and extended during a period of rainy weather. Sets 14 and 15 were in full and extended antheses during June 2 and there was a delay which became an omission for the day of a new set. But on June 3 the next two sets (16 and 17) began anthesis only seven hours apart. Then there was heavy rain and cloudiness with moderate temperatures on the 4th, during which sets 16 and 17 continued in extended anthesis with overlaps of 57 and 48 hours, and again there was an omission of a new set. Bright sunlight and rising temperature brought sets 20 and 21 into an interpolation and an overlap on each other and on set 19; and from 7:00 to 9:00 P.M. on June 7 there were 3 different sets of flowers widely open. Then there was a shift to shorter periods of anthesis (20, 21, and 22) that were more like those (Nos. 1–11) of the early part of the period of flowering.

The climax in both the extension of the anthesis and the day by day variations in anthesis is seen in the Lemon Daylily. There are wide variations in the length of anthesis, in the precise hours of its duration, and in the location of all the time-points. The variations in the different sets of flowers during a season of flowering reveal a sensitiveness to environmental influences that surpasses all other species thus far studied. But on any one day the flowers of each of the sets of the numerous ramets of the clone in a locality will be alike in a remarkable degree of synchronism.

The retarded, delayed, extended, and interpolated reactions of antheses must, it would seem, indicate physiological conditions in the plant that are more or less localized in the individual scapes.

In regard to the character and the degree of the extended anthesis, the three types *H. Thunbergii*, *H. minor*, and *H. flava* show marked differences or specificity. All three have an anthesis that is decidedly nocturnal. For *H. Thunbergii* the extension of anthesis into the following period of daylight is irregular from day to day as shown by the long interval of *c–d*. For *H. minor* the extension of anthesis into the following period of daylight is greater than that of *H. Thunbergii* as shown in the position of the *c* time-point at 4:00 P.M. For *H. flava* the extension of anthesis is still greater.

THE ANTHESES OF F_1 HYBRIDS

In most of the twelve groups of the F_1 hybrids included in this report there were at least ten individuals in good bloom and in some there were as many as fifty. With respect to the anthesis of their flowers the members of each of these groups were remarkably uniform on any one day of blooming.

The c-anthograms for these groups of hybrids combine observations of several sets at intervals of from three to four hours and also numerous observations during parts of different antheses. There has not been opportunity since these data were obtained in 1941 to make somewhat continuous observations over a series of days, as was done for *H. flava*, for hybrids and their parents which are in flower on the same days.

The c-anthograms of figure 4 are, it is certain, very accurate in indicating the value of the *b–c* interval, the extent of the various antheses, and the fluctuations in time-points for each group of hybrids. It is certain that more complete data for more sets of flowers could *not reduce* the time-intervals of opening and closing or make greater the *b–c* value, and these are the features of special importance in the evaluations.

Hybrids of Parents That Have Diurnal Anthesis. The first six c-anthograms from the top in figure 4 are for F_1 hybrids of species that have diurnal anthesis. In all cases these F_1 hybrids also had diurnal anthesis, but when comparisons with the parents are made there are some differences to be noted.

1. *H. esculenta* × *H. aurantiaca*. Series 2113. For this series the *1–4* interval was somewhat more extended than was the corresponding period in the seed parent, and it was still more extended than that of the pollen parent. As shown in the c-anthogram the common *b–c* interval was reduced to only 3 hours and the *a–b*, *c–d*, and 3–4 intervals were somewhat extended. Hence these F_1 hybrids were more variable than were the respective parents under the day by day changes in the environmental factors that affect flower opening.

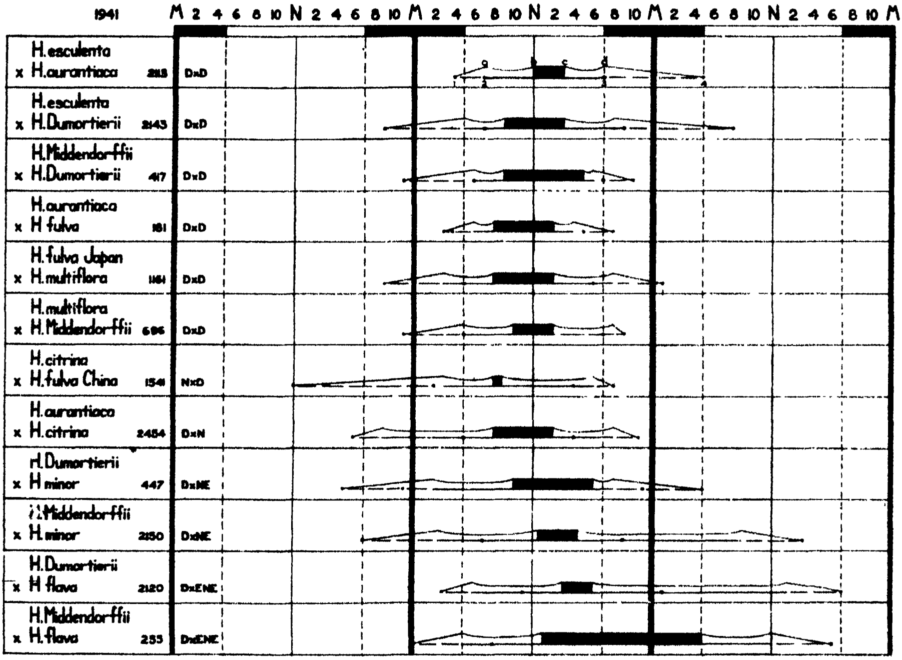

FIG. 4. C-anthograms for 12 groups of F_1 hybrids of *Hemerocallis*.

2. *H. esculenta* × *H. Dumortierii*. Series 2143. The c-anthogram for these hybrids shows in comparison with the two parents slight reduction in the intervals for *b–c* and only slight differences in the location of the points *a* and *d*, but there is a noticeable extension of the interval 3–4.

3. *H. Middendorffii* × *H. Dumortierii*. Series 417. The c-anthogram for this group of hybrids is noticeably similar to those of the two parents. The *b–c* interval is not reduced; but the *a–b* and *c–d* intervals are somewhat shorter.

4. *H. aurantiaca* × *H. fulva* Europa. Series 181. There are only very slight differences between the c-anthograms of this group and those of its two parents. The diurnal antheses of the parents and the group of hybrids were quite alike.

5. *H. fulva* "Japan" × *H. multiflora.* Series 1161. The seed parent is diurnal in anthesis but only few observations have been made on the time-points and the intervals. In comparison to the *H. multiflora* this group of hybrids had a shorter *b–c* interval but longer intervals for all other values.

6. *H. multiflora* × *H. Middendorffii.* Series 696. The anthesis of these hybrids shows decided decrease in the *b–c* interval and considerable increase in the intervals *a–b* and *c–d.* Thus there was greater variability from day to day during the season of flowering than was seen in the antheses of the two parents.

F_1 Hybrids Which Have One Parent That Has Diurnal Anthesis and One Parent That Has Nocturnal Anthesis.

7. *H. citrina* × *H. fulva* var. *rosea* clone "Rosalind." Series 1541. Twenty-five hybrids of this parentage were grown during several years. They were remarkably uniform in stature, habits of growth, flower coloring, season of bloom, and anthesis. The data which are compiled in the c-anthograms shown in figure 4 were obtained from four of these hybrids. The observations were made between June 30 and July 16 during the time when both parents were also in bloom. The data collected were complete for ten different sets of flowers, and on each day of the observations only very slight differences were observed in the antheses of these four plants.

The anthesis was diurnal in that the hours of the *a–d* interval ranged between 3:00 A.M. and 6:00 P.M. and the latest time-point for the fully closed condition was at 8:00 P.M. Yet the anthesis was nocturnal in that no set started to open (point *2*) later than 2:00 A.M. It was the rule that the flowers opened slowly and that the time-intervals of the opening of flowers (*1–2* and *1–a*) were extended. In its extent, the interval *1–4* of the c-anthogram for these hybrids includes almost *all of the combined 1–4 intervals of the two parents.*

Thus the antheses of these hybrids show the influence of both parents. The diurnal parent has somewhat greater influence especially if one considers the position of the *a–d* interval. But the variations from day to day were increased to the degree that there was only *one hour* (8:00 to 9:00 A.M.) during which flowers were widely open *on every day* of the observations. It is also to be noted that this time-period (*b–c*) was shifted to mid-forenoon which is an intermediate position with respect to the mid-points of the *b–c* intervals of nocturnal and diurnal antheses.

In somewhat casual observations throughout the blooming period one would be likely to conclude that these particular hybrids have a diurnal anthesis and that the diurnal habit is dominant to the nocturnal habit. That this is not the case is shown by the decidedly nocturnal inception of anthesis and the greater variability of the hybrids. They are much more sensitive to variations that occur from day to day in temperature and sunlight than is either of the parents. Part of the time their anthesis was more like that of the nocturnal parent and part of the time it was more like the diurnal parent. The interplay of these two heredities reduced the *b–c* interval to one hour and the longest *a–c* interval to six hours. But all the time the influence of the nocturnal parent is evident in the inception of anthesis while that of the diurnal parent is most evident in the time-period (*a–d*) of complete opening.

8. ***H.** aurantiaca* × ***H.** citrina.* Series 2454. There were two series of these hybrids and a total of 28 individuals. Observations were made on the complete anthesis of *one* large well-grown plant during the hours of daylight on each of 11 different days between July 3 and July 15. Also data were recorded for all the other sister plants during ten of these days. For these F_1 hybrids there were wide differences in habit of growth and color of flowers, characters for which the clone *H. aurantiaca* is heterozygous, but there was remarkable uniformity in their anthesis. However, the c-anthogram given in figure 4 is for *one* individual that appeared to be representative of the group.

For this hybrid the *b–c* interval of the c-anthogram was decidedly diurnal (8:00 A.M. to 2:00 P.M.) but it was earlier in its time-range than was this interval for *H. aurantiaca* (10:00 A.M. to 4:00 P.M.). The *d* and the *4* time-points were very close to those in the behavior of *H. aurantiaca*, but the *1* point was ten hours earlier.

In the anthesis of these F_1 hybrids the diurnal habit is somewhat evident but there is an extension of anthesis into the preceding nocturnal period. There is greater variation from day to day than was observed in either parent. The hybrids of *H. aurantiaca* × *H. citrina* show less variation from day to day than do the hybrids of *H. citrina* × *H. fulva* clone "Rosalind," reported in the preceding paragraphs, but there is much the same combination of nocturnal and diurnal features.

F_1 Hybrids Which Have One Parent with Diurnal Anthesis and One Parent with Extended Anthesis.

9. ***H.** Dumortierii* × ***H.** minor.* Series 477. The anthesis of these hybrids was decidedly diurnal in respect to the *b–c* interval. In its extent this interval of 8 hours was the same as that of the diurnal parent but it was much shorter than that of the *H. minor*. But the time-points for inception of anthesis (*1* and *2*) fall at 5:00 P.M. and 7:00 P.M. which are close to the location of these time-points in the antheses of *H. minor*.

In regard to the start of the opening of their flowers these hybrids were nocturnal quite like *H. minor*, but the complete opening was delayed until its completion was definitely diurnal in character. The *2–4* time-interval was 24 hours in extent and its time-points came almost at midnight. Thus there was much increase in the extent of anthesis over that of *H. Dumortierii*. There was however no overlap of two sets fully open.

10. *H. Middendorffii* x *H. minor*. Series 2150. The c-anthogram for these hybrids shows a *b–c* interval of only 4 hours that extends from 12:30 P.M. to 4:30 P.M. This is definitely diurnal and reflects an influence of the *H. Middendorffii* parent.

But the preceding *a–b* interval covered 10 hours and the following *c–d* interval was one of 16½ hours. Hence there was a noticeable extension of the time-interval when some flowers were fully open. The overlap of two sets fully open was rather frequent between 5:00 A.M. and 9:00 A.M. These extensions show an influence of the *H. minor* parent. The much shorter value of *b–c* in the hybrids indicates that the day by day antheses of the hybrids were much more variable than those of either parent. There was remarkable uniformity in the antheses of the various members of the hybrid group on any one day but the hybrids were more sensitive to the daily alternations of daylight and darkness than was either of the two parents.

The antheses of the two species *H. Dumortierii* and *H. Middendorffii* are quite similar (see figure 1) but the antheses of the two groups of hybrids obtained when they are crossed with the one species *H. minor* are noticeably different.

11. *H. Dumortierii* × *H. flava*. Series 2120. In these hybrids the inception of anthesis, the position of the *a* time-point, and the position of the *b–c* time-intervals were all diurnal; but there was marked extension of the anthesis as seen in its *1–4* and *a–d* time-intervals. These included a diurnal, the following nocturnal, and another diurnal period,—an extent of 30 hours. The combined periods of antheses of the hybrids was somewhat shorter in extent than the longest anthesis of a single set of the *H. flava*. It is certain, however, that the variations in the hybrids are less in degree than are those in *H. flava* as evaluated by the various time-intervals but much greater than those of the diurnal parent.

The inception of anthesis is decidedly diurnal in both parents, and this is the case in the hybrids. The time-intervals of the extent of anthesis (*1–4* and *a–d*) are much greater than those of *H. Dumortierii* but less than those of *H. flava*. In the hybrids the overlap of sets was most frequent in the forenoon.

The overlap of two sets between 10:00 A.M. and 2:00 P.M. has been illustrated in photographs (Stout 1934) of the flowers of the "Gold Dust Daylily," one of the early horticultural clones of the F_1 hybrids of *H. Dumortierii* and *H. flava*.

12. *H. Middendorffii* × *H. flava.* Series 255. These particular F_1 hybrids were very uniform in flower behavior, habit of growth, and character of flowers. Only five of a rather large progeny were kept and these were large well-grown plants with numerous flowers when this study of anthesis was made.

These hybrids had the longest common interval of full anthesis (*b–c*) observed thus far in any group of hybrids or in any species except *H. minor* and *H. flava.* This period (*b–c*) extended from 1:00 P.M. to 5:00 P.M. of the following day. The *a–d* interval extended to 31 hours, from 5:00 A.M. until noon of the following day, and there was frequently an overlap in the antheses of two sets of flowers during the forenoon.

In comparison with the hybrids of *H. Dumortierii* × *H. flava* there was almost the same extent (*1–4*) of anthesis, but there was much less fluctuation in the time-points of closing (*c–d*) and a much longer interval (*b–c*) of common full anthesis.

SUMMARY AND CONCLUDING REMARKS

1. **Specificities of Anthesis.** (a) Among the relatively few species of the genus *Hemerocallis* there are three distinctly different main types of anthesis which are characteristic hereditary specificities. As far as is known the majority of the species have diurnal anthesis, and the flowers of all these are clear orange or fulvous red in color. Two species have nocturnal anthesis, and these have pale yellow flowers which are odorous. Three species have extended anthesis, but to different degrees, and these have yellow flowers which are odorous. Flowering periods of diurnal species are distributed over the entire season of spring, summer, late summer, and early autumn. Of the two nocturnal species, one flowers in midsummer and one in late summer and early autumn. Two that have most extended anthesis (*H. minor* and *H. flava*) bloom in spring at the same time that certain diurnal species bloom, and one (*H. Thunbergii*) flowers in midsummer. Thus the types of anthesis are specificity characters that are not differentiated according to a particular season in the collective period of flowering.

(b) The diurnal and the nocturnal habits of anthesis in *Hemerocallis* exhibit sharp contrasts and specific differentiation. There is no overlap of the time intervals of common full anthesis (*b–c*) of these two types. In the diurnal type the processes which bring about the climax of flower maturity and the action of the mechanism of anthesis operate in a synchronized relation with the hours of daylight; in the nocturnal type they are synchronized with the hours of darkness. Temperature, and perhaps humidity, as well as sunlight exert noticeable influence on various features of the expression of anthesis.

(c) The extended type of anthesis combines various features of both the diurnal and the nocturnal habits. The three species that were studied exhibit different and definitely progressive degrees in the extensions of anthesis.

H. Thunbergii has an anthesis that is primarily nocturnal and there is poor opening and much irregularity during the extension into a part of the following diurnal period.

The anthesis of *H. minor* is also nocturnal at the start but is more stabilized in a greater extension into the following period of daylight.

The anthesis of *H. flava* has the most extended anthesis thus far observed in the species of daylilies; but there is much variation in the antheses of the various sets of flowers. The anthesis is somewhat diurnal in its beginning and more than half of the sets attain full opening in the hours of the afternoon. But the majority of the sets continue in anthesis throughout the following hours of darkness and through at least a part of the second period of sunlight. There are wide variations in the time periods of anthesis.

Thus the *initiation* of extended anthesis is strongly nocturnal in two species and strongly diurnal in one species. The conclusion of the extended anthesis is not closely correlated with the next period in the alternation of daylight and darkness. The time-points of closing are especially fluctuating in response to those variations in weather which have relatively little effect on the anthesis of diurnal species. Also the conditions which induce extreme extensions of anthesis in *H. flava* also retard the development and maturity of the next set of flowers. Thus when two extended sets are widely open during a second period of daylight there is usually an omission of a new set for that day.

2. **Summary of the Heredity of Anthesis in F_1 Hybrids.** (a) It is the general rule that the F_1 hybrids of *Hemerocallis* tend strongly to have features of diurnal anthesis. But there is also, in every case, definite influence of the genom derived from a parent that has either nocturnal or extended anthesis. Thus there are features of both types of anthesis with somewhat noticeable modifications of each.

(b) The F_1 hybrids of diurnal × diurnal parentage have diurnal anthesis. But there is some evidence that such hybrids are often somewhat more variable and less stabilized in the reactions of the inception and the completion of anthesis.

(c) The F_1 hybrids of diurnal × nocturnal parentage have an anthesis that is strongly diurnal. But both of the different genoms exert influence and no anthesis of a set is precisely like that of either parent for that same day. Also the hybrids are more sensitive and variable from day to day. The composite time-intervals for inception (*1–2* and *a-b*) and completion (*c–d*) of anthesis show greater range of variability and in one group of hybrids these variations reduced the *b–c* period to only one hour.

(d) The behavior of four groups of F_1 hybrids of combinations of two diurnal species and two of extended habit indicates that neither type of anthesis is fully dominant, but that the influence of each parent may be recognized. The anthesis is strongly diurnal in inception, but is less so for hybrids of *H. minor* than for hybrids of *H. flava*.

For the hybrids which have *H. minor* for a parent there was extended anthesis nearly equal to that of *H. minor*, but there was much greater variation especially in the opening of flowers.

The two groups of hybrids which have *H. flava* for a parent had anthesis that was diurnal in the inception and more extended than that of the diurnal parent but less extended that *H. flava*. There was a somewhat unexpected difference in the variability of the two groups of hybrids, although the two diurnal parents were rather similar in anthesis.

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BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 73, No. 2, pp. 155–166 MARCH, 1946

THE MOSSES OF GEORGIA—II. THE COASTAL PLAIN[1]

RUTH O. SCHORNHERST

Only three papers dealing exclusively with the mosses of Georgia have been published, none treating the Coastal Plain section of the state. Many scattered references to Georgia collections are found in Grout's *Moss Flora*, and in papers by McVaugh, Anderson, *et al.* These, added to data from my own collections, those of J. K. Small, and herbarium material from the New York Botanical Garden and the University of Michigan, have served as the source of material for the present paper and the one to follow. The result is a surprisingly lengthy list of species, although several which might be expected to occur are not included, owing mainly to the haphazard nature of most of the collecting. Before publishing this list I had expected to do more personal collecting and to make further study of important southern collections such as that at Duke University, but travel restrictions due to the war have prevented. Although I realize the limitations of the present list, I feel that it is large enough and representative enough to present as a preliminary report.

Georgia lies within two of the major physiographic regions of the United States, the Atlantic Plain on the southeast and the Appalachian Region on the northwest. The latter includes parts of four provinces: the Central Upland, the Appalachian Mountains, the Appalachian Valley and Ranges, and the Appalachian Plateau (fig. 1). The present paper deals exclusively with the Coastal Plain; the other regions, with the exception of the Appalachian Plateau, which has been covered by the recent paper by Carroll (1945), will be treated later.

The Coastal Plain, bordering the coast of the United States from southern New England to and into Mexico, occupies all of Georgia south of a crooked line connecting Augusta, Milledgeville, Macon, and Columbus (fig. 1). This crooked line is the Fall Line, a transition zone some five to ten miles wide, marking the coast line of an earlier geologic era. It is easily observable in the streams, where rapids and falls develop (hence the name), but is often difficult to discern on the ridges between since there are no appreciable soil differences between the two regions. The Piedmont, just north of the Fall Line, is underlain by ancient granites and other crystalline rocks, while to the south of it underlying the surface soils are softer sedimentary rocks such as limestone, or in some places clay or sand. Approximately three-fifths of the total area of the state, 35,650 square miles,

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[1] The first paper of this series appeared as: Mosses of Stone Mountain, Georgia. Bryologist 48: 29–33. 1945.

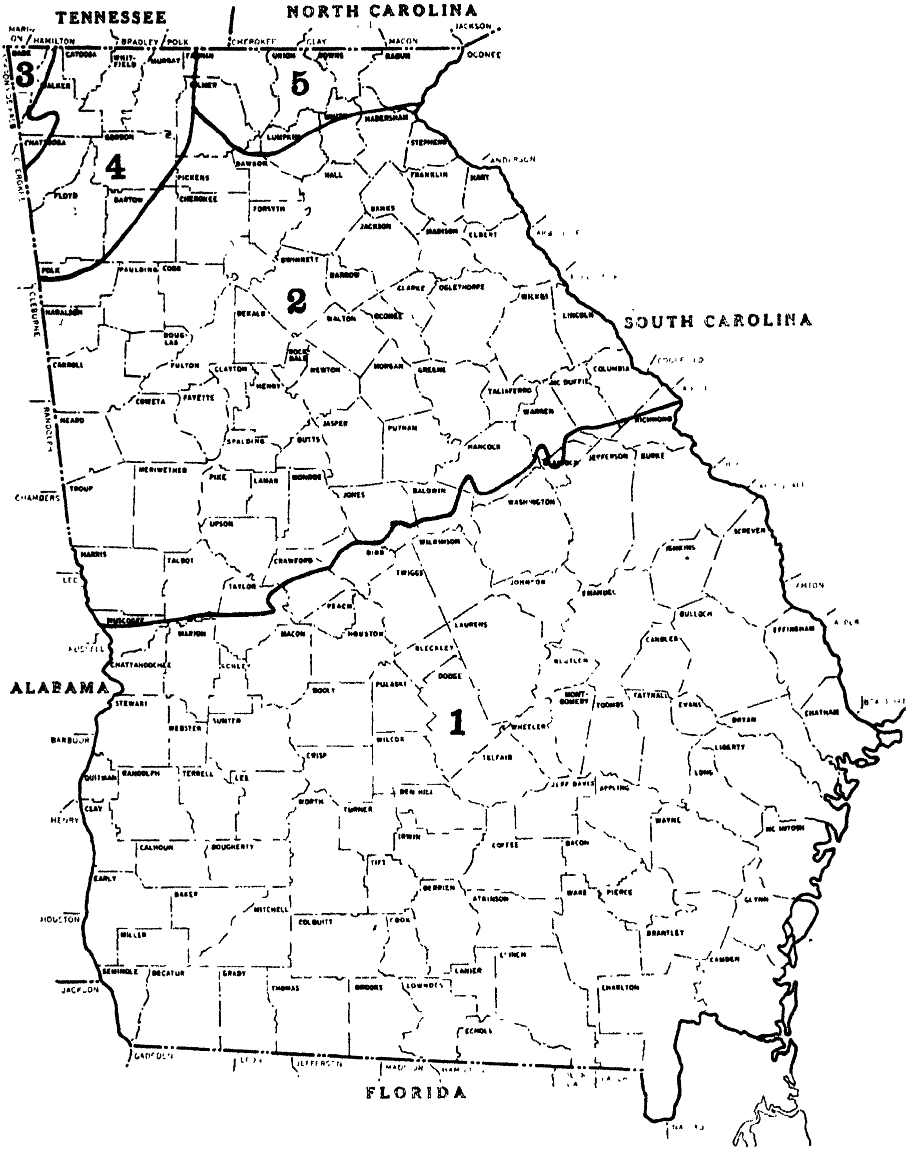


FIG. 1. Map of Georgia, showing the provinces. 1. Coastal Plain. 2. Central Upland. 3. Appalachian Plateau. 4. Appalachian Valley and Ranges. 5. Appalachian Mountains.

is included in the Coastal Plain. The topography is partly rolling, partly flat. The underlying formations are mantled by a wide variety of soils, including red clay, gray limestone soils, and light-colored sands. Some of these soils represent greatly decomposed formations like the Alum Bluff, others are Pleistocene in origin. Streams rising within the Coastal Plain are clear, owing to the leaching by sandy banks and beds, but those rivers rising to the north and flowing across it are for the most part turbid and discolored by dissolved organic matter. Lakes, sometimes numerous, may be original depressions or may be formed by solution of limestone. Some of these lime-sink lakes are quite large and deep. Along the Savannah River occur lakes which are nothing more than abandoned river channels. Swamps are abundant in the southern parts of the Coastal Plain, where the ground is frequently low. Best known of these swamps is the Okefenokee Swamp, an original depression covering 660 square miles, second in size in the United States only to the Dismal Swamp of Virginia. At least five coastal terraces, derived from sea bottom and converted into land by the withdrawal of the sea to a lower level, are recognized (LaForge, Cooke, *et al.*).

The southern states are conspicuous for the exceedingly heavy growth of bryophytes and other small plants which thrive where moisture is abundant and where growing conditions foster long periods of vegetative growth. The southern half of Georgia has a warm, moist climate, with long summers having frequent and heavy rainfall, and with short mild winters. The growing season (from last spring frost to first fall frost) averages 250 days near the Georgia-Florida border, and rainfall ranges from 50 to 55 inches per year. These figures are representative of the general climatic situation in most of the Georgia Coastal Plain.

The states bordering the Gulf of Mexico are of considerable significance to one interested in the distribution of plants. The majority of species of mosses found here, it is true, are typical of much of eastern North America, but the area is a critical one for studying the mingling of temperate and tropical or subtropical species. Interest in any area not previously studied intensively centers around the unusual or unexpected species found there. For example, to list such ubiquitous species as ***Bryum argenteum*** or ***Polytrichum commune*** would not cause much excitement in the bryological world, but when characteristically tropical species such as ***Syrrhopodon ligulatus***, ***Fissidens subcrenatus***, or ***Mittenothamnium diminutivum*** are found in the same region as ***Haplohymenium triste*** or ***Platygyrium repens***, characteristic of more northern localities, then one realizes that the region needs close scrutiny.

Anderson (1938) listed 38 species of mosses commonly found in the Coastal Plain of North Carolina. Of these, 18 are known from the Georgia Coastal Plain, and at least eight others probably occur more or less frequently, for they do in northern Florida, which is much like southern Georgia in topography, climate, and vegetation-types. Figure 2 shows the distribution of ***Bruchia Donnellii***, a species confined to the Coastal Plain, while figures 3 and 4 show the distribution of *Tetraplodon pensylvanicus* and *Cryphaea glomerata* which, although not restricted to the Coastal Plain, have their greatest concentration there. Other characteristic species are *Syrrhopodon texanus, Homalotheciella fabrofolia, Sphagnum macrophyllum, Sphagnum henryense, Sphagnum portoricense, Entodon Drummondii, Pogonatum brachyphyllum*, and *Ptychomitrium Drummondii*. Such species as *Clasmatodon parvulus, Plagiothecium micans, Schlotheimia Sullivantii*, and *Schwetschkeopsis denticulata* are found throughout the southern states, while *Cirriphyllum Boscii, Thelia hirtella, Entodon seductrix, Sciaromium Lescurii, Climacium Kindbergii*, and *Leucodon julaceus* are widely distributed throughout eastern North America. Some species, such as *Plagiothecium micans, Leucodon julaceus, Forsstroemia trichomitria*, and *Weisia viridula* probably grow in every county in the state. *Fontinalis Sullivanti* has been considered a Coastal Plain species, but it seems more characteristic of the entire eastern part of the country, being known from Florida, Georgia, Louisiana, Alabama, Missouri, Arkansas, Tennessee, Delaware, New Jersey, Pennsylvania, New York, Connecticut, Massachusetts, Maine, and Nova Scotia (Welch, in litt.).

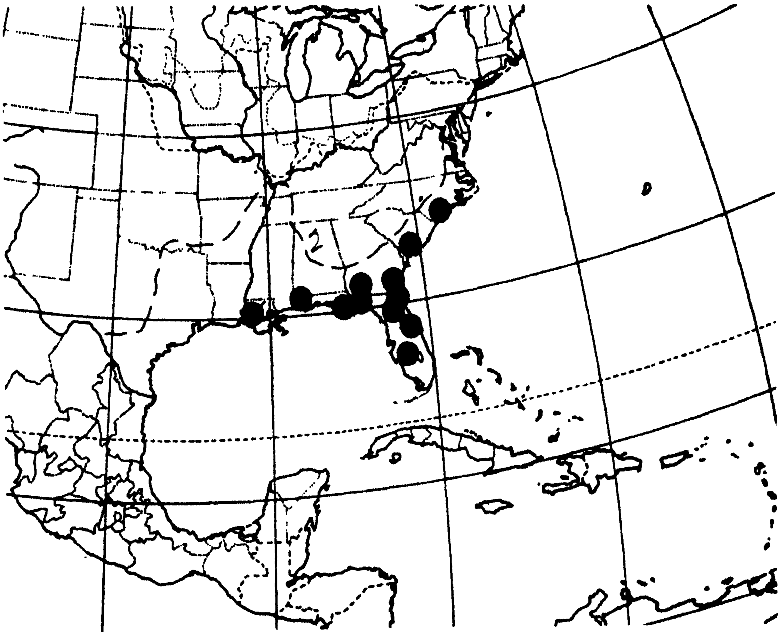


FIG. 2. Distribution of *Bruchia Donnellii*.

In recent years a number of writers have shown that present distribution of plants can be better interpreted if we know something of their past distribution. One collection of fossils in South Georgia and one in northern Florida give the only clue so far to the fossil fauna and flora of the Georgia Coastal Plain, but that clue is significant. The Miocene of Florida and Georgia consists of three formations, the Chattahoochee, the Chipola, and the Chesapeake, in order of age (Foerste). During the early Miocene the

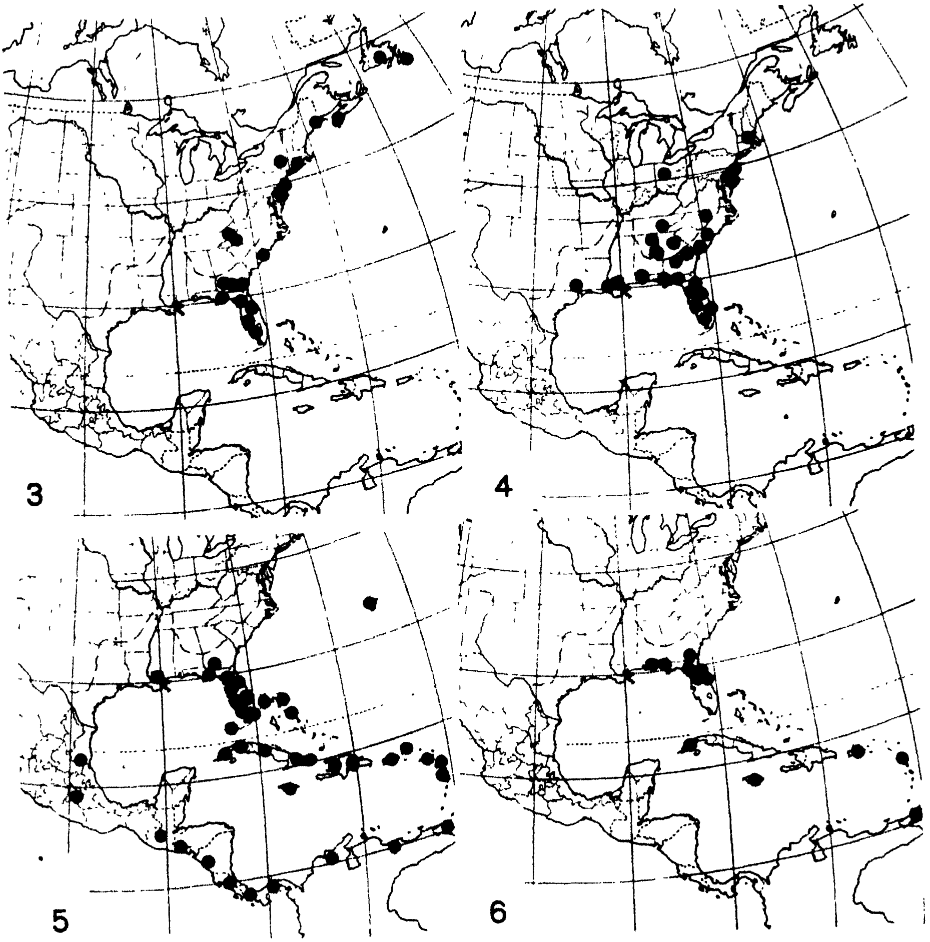


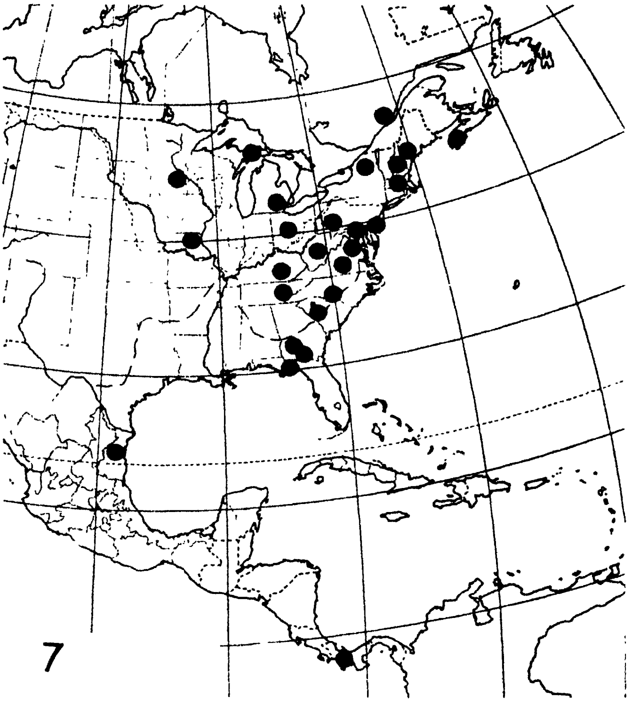
FIG. 3. Distribution of *Tetraplodon australis*. FIG. 4. Distribution of *Cryphaea glomerata*. FIG. 5. Distribution of *Mittenothamnium diminutivum*. FIG. 6. Distribution of *Syrrhopodon ligulatus*.

Okefenokee Current, a return-current from the Gulf of Mexico, went through the Okefenokee Straits. The Chipola fauna, of decidedly subtropical (Antillean or Caribbean) facies, extended all along this passage and some distance northward. Collections made between Bainbridge and Fowlstown, in Decatur County, show this clearly. Later the Chesapeake, a cold southwest-running current, introduced northern forms of marine life all along the southern border of the Miocene continent. The Alum Bluff formation in northern Florida, forty miles southwest of the Georgia deposits, indicates much the same condition, namely, a tropical flora receiving replacements and additions from a more temperate one (Berry). The present situation in peninsular Florida, and to a very limited extent in southern Georgia, is that of an essentially temperate flora receiving additions from the tropics. Examination of the spot maps (showing known collections) of *Mittenothamnium diminutivum* or *Syrrhopodon ligulatus* (figs. 5, 6) will show tropical species which have reached their northern limit in southern Georgia, only a few miles from the Bainbridge fossil area.

Sharp (1944) has called attention to the large number of mosses common to the areas north and south of the Mexican–United States boundary (142 species). Of these thirty occur occasionally in southern Georgia. Outstanding examples are *Campylopus fragilis*, *Campylopus gracilicaulis*, *Dicranella Herminieri*, *Dicranella Hilariana*, *Barbula Crügeri*, *Fissidens polypodioides*, and *Rhizogonium spiniforme*. Seventy of these species are known from peninsular Florida, many from almost every county. The hot, humid conditions which seem necessary for most of these tropical and subtropical mosses change rapidly as soon as the moderating effects of the Gulf of Mexico and the Atlantic Ocean are left behind. Only a few miles produce noticeable effects.

There is not much conclusive evidence of the extension of northern species southward into the Coastal Plain; the transition is too gradual. Many species which are for the most part restricted to more northerly regions extend southward wherever conditions are suitable. Although *Haplohymenium triste* occurs rather frequently in other southern states to the north of Georgia, it has been reported only twice in Florida and twice in southern Georgia. This makes it appear to be moving into the Coastal Plain (fig. 7). *Platygyrium repens* is another northern species found only occasionally in the southern Coastal Plain (fig. 8). This situation is probably true of many small plants. Too frequently oversight has been taken for absence.

Few intensive studies of the distribution of a single species of moss have been made. If such material were available, many of our spot maps would show more continuous distribution from one section of the country to another. One of the best studies of this sort is that of Anderson on *Tortula pagorum* (1943), a species which, although spotty in occurrence, usually grows abundantly wherever it is found. Scarcity of elms in southern Georgia and Florida may account for its absence in those regions, although Anderson has found it growing on live oaks, pecans, and other ridged-barked trees in addition to its usual elm habitat. It reaches its maximum development in the Piedmont, but is sufficiently common in the Coastal Plain, where it



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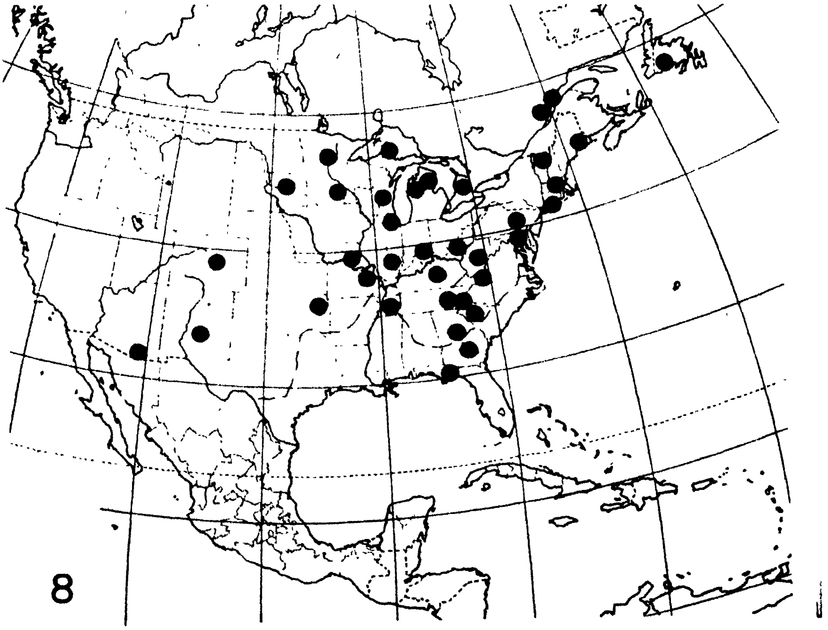

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Explanation of figures 7 and 8

FIG. 7. Distribution of *Haplohymenium triste*. FIG. 8. Distribution of *Platygyrium repens*.

occurs erratically, to be rather striking. It has been collected in 12 counties in the Georgia Coastal Plain, and 154 stations in all are known for this species.

Among the mosses with limited distribution not already discussed three others are interesting enough to receive comment. *Fissidens subcrenatus* is known from Puerto Rico (as *F. pellucidus*), from two stations in Mexico, one in Florida, and one in Georgia (Loundes County). In 1930 Roland M. Harper, who made this Georgia collection, also collected a new species, *Rhynchostegiella georgiana*, in a swamp about two miles south of Macon, in Bibb County, at the edge of the Coastal Plain; so far as I know this species is not known from any other station. *Solmsiella biseriata* (as *Erpodium biseriatum*) was collected near Augusta by Sullivant in 1845, but has never been collected again.

LIST OF SPECIES

Nomenclature follows the lists of mosses and *Sphagnum* in the special check-list number of *The Bryologist* (vol. 43, Oct. 1940). Since no check list of species of mosses occurring in Georgia is available, county records are included. In a few instances this procedure could not be followed, for some of Dr. Grout's collections from the Okefenokee Swamp bore no location data. These are marked simply "Okefenokee."

POLYTRICHACEAE

Catherinaea Macmillani Holz. Glynn, Grady, Thomas.
Pogonatum brachyphyllum (Rich.) Beauv. Dodge, Loundes, Randolph, Richmond, Thomas.
Pogonatum pensilvanicum (Hedw.) Paris. Randolph.
Polytrichum commune Hedw. Loundes, Okefenokee.

FISSIDENTACEAE

Fissidens adiantoides Hedw. Clay, Sumter.
Fissidens Bushii Card. & Thér. Thomas.
Fissidens minutulus Sull. Richmond, Stewart.
Fissidens osmundioides Hedw. Decatur, Grady.
Fissidens polypodioides Hedw. Grady, Thomas.
Fissidens Ravenelii Sull. Grady, Thomas.
Fissidens subbasilaris Hedw. Thomas.
Fissidens subcrenatus Schimp. Loundes.
Fissidens viridulus (Web. & Mohr) Wahlenb. Grady, Richmond.

DITRICHACEAE

Bruchia Donnellii Aust. Thomas, Ware.
Ditrichum pallidum (Hedw.) Hampe. Grady, Thomas.
Pleuridium Ravenelii Aust. Richmond.
Pleuridium subulatum (Hedw.) Lindb. Loundes, Richmond.

DICRANACEAE

Campylopus fragilis (Dicks.) Bry. Eur. Okefenokee, Ware.
Campylopus gracilicaulis Mitt. Ware.
Dicranella Herminieri Besch. Randolph, Thomas.
Dicranella heteromalla (Hedw.) Schimp. Glynn.
Dicranella Hilariana (Mont.) Mitt. Loundes, Randolph, Thomas.
Dicranella varia (Hedw.) Schimp. Loundes.
Dicranum condensatum Hedw. Camden, Richmond.

LEUCOBRYACEAE

Leucobryum albidum (Brid.) Lindb. Brooks, Chatham, Glynn, Loundes, Randolph, Richmond, Stewart, Walton, Ware.
Leucobryum glaucum (Hedw.) Schimp. Ware.

CALYMPERACEAE

Syrrhopodon floridanus Sull. Okefenokee.
Syrrhopodon ligulatus Mont. Clinch.
Syrrhopodon texanus Sull. Loundes, Okefenokee.

POTTIACEAE

Barbula Crügeri Sond. Grady, Dougherty.
Tortella humilis (Hedw.) Jennings. Bibb.
Tortula pagorum (Milde) DeNot. Appling, Bibb, Chatham, Emanuel, Jefferson, Liberty, Macon, Richmond, Sumter, Toombs.
Weisia viridula Hedw. Grady, Thomas.

GRIMMIACEAE

Ptychomitrium Drummondii Sull. Chatham, Richmond, Thomas.
Ptychomitrium incurvum (Muhlenb.) Sull. Richmond, Tatnall.

EPHEMERACEAE

Ephemerum megalosporum (Aust.) Salm. Bibb.
Ephemerum serratum (Hedw.) Hampe. Sumter.

FUNARIACEAE

Funaria flavicans Mx. Glynn, Richmond.
Funaria hygrometrica Hedw. var. patula Bry. Eur. Ware.
Funaria serrata Brid. Bibb, Chatham.
Physcomitrium turbinatum (Mx.) Brid. Chatham, Richmond, Ware.

SPLACHNACEAE

Tetraplodon pensylvanicus (Brid.) Grout. Clinch, Colquit, Ware.

ERPODIACEAE

Solmsiella biseriata (Aust.) Steere. Richmond.

ORTHOTRICHACEAE

Schlotheimia Sullivantii C. Müll. Brooks, Charlton, Effingham, Grady, Thomas.

BARTRAMIACEAE

PHILONOTIS LONGISETA (Rich.) E. G. Britton. Thomas.
PHILONOTIS GLAUCESCENS (Hornsch.) Paris. Grady, Thomas.

BRYACEAE

BRYUM ARGENTEUM (L.) Hedw. Daugherty, Grady.
BRYUM CAPILLARE (L.) Hedw. Okefenokee.

MINACEAE

MNIUM AFFINE Bland. Thomas.

RHIZOGONIACEAE

RHIZOGONIUM SPINIFORME (Hedw.) Bruch. Grady.

HYPNACEAE

AMBLYSTEGIUM VARIUM (Hedw.) Lindb. Dougherty.
BRACHYTHECIUM SALEBROSUM (Web. & Mohr) Bry. Eur. Thomas.
CAMPYLIUM CHRYSOPHYLLUM (Brid.) Bryhn. Grady, Richmond.
CHAMBERLAINIA ACUMINATA (Hedw.) Grout. Chattahoochee.
CLIMACIUM KINDBERGII (Ren. & Card.) Grout. Wayne.
ENTODON DRUMMONDII (Bry. Eur.) Jaeger & Sauerb. Thomas.
ENTODON SEDUCTRIX (Hedw.) C. Müll. Dougherty, Glynn, Grady, Thomas, Wayne.
EURHYNCHIUM HIANS (Hedw.) Jaeger & Sauerb. Dougherty.
EURHYNCHIUM RAPPII (Williams) Grout. Grady.
EURHYNCHIUM SERRULATUM (Hedw.) Kindb. Loundes, Thomas.
HOMALOTHECIELLA FABROFOLIA (Grout) Broth. Berrien, Thomas.
HOMALOTHECIELLA SUBCAPILLATA (Hedw.) Card. Sumter.
HYPNUM CUPRESSIFORME Hedw. Thomas.
HYPNUM PATIENTIAE Lindb. Thomas, Wayne.
HYPNUM PRATENSE Koch. Wayne.
LEPTODICTYUM RIPARIUM (Hedw.) Warnst. Grady.
MITTENOTHAMNIUM DIMINUTIVUM (Hampe) E. G. Britton. Grady.
PLAGIOTHECIUM GEOPHILUM (Aust.) Grout. Decatur.
PLAGIOTHECIUM MICANS (Sw.) Paris. Berrien, Charlton, Coffee, Grady, Loundes, Randolph, Sumter, Thomas, Ware, Wayne.
RHYNCHOSTEGIELLA GEORGIANA Dix. & Grout. Bibb.
SCIAROMIUM LESCURII (Sull.) Broth. Grady.
SEMATOPHYLLUM ADNATUM (Mx.) E. G. Britton. Charlton, Coffee, Grady, Loundes, Montgomery, Sumter, Tatnall, Thomas, Okefenokee.

LESKEACEAE

ANOMODON ATTENUATUS (Hedw.) Hüben. Dougherty, Thomas.
ANOMODON MINOR (Beauv.) Lindb. Dougherty.
HAPLOHYMENIUM TRISTE (Cesati) Kindb. Dougherty, Grady.
LESKEA AUSTRALIS Sharp. Dougherty.
THELIA ASPRELLA Sull. Coffee, Tatnall, Taylor.
THELIA HIRTELLA (Hedw.) Sull. Dougherty, Grady, Loundes, Thomas, Wayne.

THUIDIUM DELICATULUM (Hedw.) Mitt. Grady, Thomas.
THUIDIUM MICROPHYLLUM (Hedw.) Best. Grady.

LEUCODONTACEAE

FORSSTROEMIA TRICHOMITRIA (Hedw.) Lindb. Grady, Thomas.
FORSSTROEMIA TRICHOMITRIA (Hedw.) Lindb. var. IMMERSA (Sull.) Lindb Grady, Okefenokee.

CHRYPHAEACEAE

CRYPHAEA GLOMERATA Schimp. Richmond, Sumter.

FABRONIACEAE

CLASMATODON PARVULUS (Hampe) Sull. Charlton, Grady, Thomas.
FABRONIA RAVENELII Sull. Richmond, Thomas.
SCHWETSCHKEOPSIS DENTICULATA (Sull.) Broth. Thomas, Okefenokee.

FONTINALACEAE

BRACHELYMA ROBUSTUM (Card.) E. G. Britton. Colquitt, Jefferson, Laurens, Miller.
BRACHELYMA SUBULATUM (Beauv.) Schimp. Chatham, Wayne.
FONTINALIS DISTICHA Hook. & Wils. Wayne.
FONTINALIS SULLIVANTI Lindb. Grady.
FONTINALIS DALICARLICA Bry. Eur. Dougherty.

SPHAGNACEAE

SPHAGNUM CUSPIDATUM Ehrh. var. SERRULATUM Schlieph. Charlton, Clinch, Dodge.
SPHAGNUM CYCLOPHYLLUM Sull. & Lesq. Sumter.
SPHAGNUM HENRYENSE Warnst. Charlton.
SPHAGNUM MACROPHYLLUM Bernh. Charlton, Sumter.
SPHAGNUM MAGELLANICUM Brid. Charlton, Ware.
SPHAGNUM PALUSTRE L. Chatham, Coffee, Decatur, Richmond, Screven, Sumter, Tift.
SPHAGNUM PORTORICENSE Hampe. Charlton.
SPHAGNUM RECURVUM Beauv. Brooks, Coffee, Laurens, Randolph, Richmond, Ware.
SPHAGNUM STRICTUM Sull. Charlton, Dodge, Ware.
SPHAGNUM SUBSECUNDUM Nees. Brooks.

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THE EFFECT OF COLCHICINE AND ACENAPHTHENE IN COMBINATION WITH X-RAYS ON PLANT TISSUE—III[1]

MICHAEL LEVINE

ACENAPHTHENE

In another study made on the root-tips of the "Yellow Globe" variety of *A. cepa* the effects induced by exposures to acenaphthene were examined. This substance has been reported by Kostoff (1938a, b, c) and others as having an effect on nuclear divisions similar to if not greater than that of colchicine. It seemed of interest to study the effect of this chemical on growth and to determine its value in combination with x-rays. Several experiments with this agent were made concurrently with the colchicine studies. In one experiment 12 bulbs were germinated for 8 days and then placed in a saturated solution of acenaphthene for 48–50 hours. The root-tips were irradiated with 900r and then returned to water. Non-x-rayed acenaphthene-treated bulbs and a few chemically untreated ones were kept as controls. The treated bulbs were studied microscopically after their return to water for 13 days. A study of the acenaphthene-treated bulbs showed that the swellings induced by this chemical after an exposure of 48 hours were slight, and in most of these experiments the roots failed to retain the hypertrophies after the bulbs were returned to water for three or four days. Sections of these root-tips were studied and brief reference will be made to these preparations below. In both the acenaphthene-treated controls and the acenaphthene-x-rayed bulbs many of the roots became water-soaked and flaccid, although it appeared that new roots had been formed (fig. 6). Outgrowths of the 48-hour-acenaphthene-x-rayed roots were small and became completely arrested (bulbs 21, 29, 30) five days after their return to water, while the bulbs treated with acenaphthene alone (bulb 9) showed marked growth, although the swellings on the long roots were barely distinguishable. Compared with those obtained with colchicine at the concentrations used here, the reactions were much slower and weaker.

In another experiment fifteen onions were germinated in water for seven days, after which six were placed into 0.01 per cent solution of colchicine, six in a saturated solution of acenaphthene, and three were chemically untreated. After 48 hours of exposure to the substances, the roots of three bulbs from each group, with two of the untreated bulbs, were irradiated with 3000r. All the bulbs in the series were then returned to water. Samples from each group were photographed after their return to water (fig. 37). Bulb 3 was colchicinized and irradiated, bulb 6 was colchicinized only, and bulb 13 was irradiated only. Bulb 11 was immersed in acenaphthene and irradiated, bulb 9 was treated with acenaphthene only, while bulb 15 was untreated. The irradiation was administered, as already described, for 30 minutes at 100r per minute.

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[1] Previous parts of this study appeared in Bull. Torrey Club **72**: 563–574; **73**: 34–59.

A comparison of the colchicine-treated and acenaphthene-treated bulbs six days after their return to water (bulbs 6, 9) showed strikingly the difference in effect produced by these substances under similar conditions. The terminal outgrowths from the diminutive hypertrophies on the acenaphthene-treated roots were longer than those on the colchicinized bulbs; secondary roots were formed from both.

The growth-retarding effects were more pronounced after colchicine-irradiation treatment than after acenaphthene-irradiation. Considerable elongation of the root-tips occurred after the latter treatments (compare bulb 3 with 11) when the bulbs were returned to water for 6 days. The roots on the irradiated control bulbs (bulb 13) elongated slightly and some secondary roots were formed. The water controls grew actively and formed numerous secondary roots (bulb 15). It appears obvious that acenaphthene is not so active as colchicine as a ''tumor''-producing agent. The hypertrophies are small, but the division stages appear to be as numerous in both types of chemical treatment for a given exposure. The acenaphthene activity seems to be limited by the insolubility of the compound. Levan (1940) reached a similar conclusion. The need for covering the roots with the crystals before any gross visible action is induced detracts from the usefulness of this agent in these studies.

Microscopic studies made of this series of root-tips confirmed the observations reported above. In root-tips taken from bulbs irradiated with 3000r after acenaphthene and returned to water for 13 days (fig. 38) the meristem was reduced in volume. It was represented only by a small collection of embryonic cells. A comparatively thick layer of collapsed cells covered the remaining terminal portion of the root. The terminal cells were empty. The plerome tissue was well differentiated and contained a number of viable cells in division stages. Normal spiral vessels were found in this tissue. The cortical cells appeared normal and well differentiated. Root-tips from the irradiated colchicinized bulbs showed more intense destruction than in the irradiated controls. The cells were more mature and larger, nuclei were densely stained although some appeared well differentiated. The number of viable cells appeared to be smaller (fig. 39). More empty, highly vacuolate cells were found in the cortical parts of the root. The number of cells in the remainder of the meristem was small. Spiral vessels were not common but present. Cytologically, the acenaphthene-treated and irradiated (3000r) root-tips appeared much like the root-tips irradiated only.

In another experiment the effects of colchicine and 1500r were contrasted with those of acenaphthene and 1500r. The root-tips of 15 onions of the "Yellow Globe" variety were used. Six bulbs were exposed to colchicine, and six to a saturated solution of acenaphthene for 48 hours and three were chemically untreated. Seven of these bulbs (3 colchicine, 3 acenaphthene, 1 untreated) were irradiated with 1500r. After the irradiation, all bulbs were returned to water. The colchicinized bulbs recovered; new outgrowths appeared from the bulbous tips together with many secondary roots. The root-tips of the colchicinized and irradiated plants made no outgrowths or little protuberances from the hypertrophied tips; no secondary roots were formed (fig. 40). The root-tips treated with acenaphthene for 48 hours and irradiated (1500r) resumed growth after having been returned to water for six days (fig. 40, bulb 25). This growth was not strikingly less than that of the acenaphthene-treated bulbs without irradiation (fig. 40, bulb 23). The hypertrophies were small and in both series were barely perceptible after their removal from water. It seems that the injury here was considerably less than with the colchicinized-irradiated root-tips. The acenaphthene-treated and irradiated root-tips resembled more closely the root-tips which were irradiated only (fig. 40, bulb 28). A comparison between the colchicinized-irradiated and acenaphthene-treated and irradiated root-tips showed unquestionably that the former treatment delayed and impaired growth more actively than the latter. The roots of the non-irradiated non-chemically treated plants (fig. 40, bulb 29) appeared longer than the others, they had been growing in water for 16 days.

Microscopical examinations of these chemical-treated root-tips were made immediately before and after irradiation and after their return to water. The observations on these colchicine-treated bulbs were similar to those described above. The colchicinized-irradiated roots, examined 11 days after their return to water showed some destruction of their peripheral tissues, yet a center of viable meristematic cells was always present. In contrast with this stage the irradiated but chemically untreated root-tips were normal in structure four days after their treatment. Some cells were in division stages and no visible impairment of structure or function was seen (fig. 41). When roots from these bulbs were examined microscopically 11 days after their return to water, they had few dividing cells. Many peripheral cells were empty and the walls were deeply stained. The nuclei appeared to be contracted, although clearly differentiated.

A number of fixations were made from the root-tips of acenaphthene-treated bulbs (fig. 40, bulb 23). Metaphases were abundant and resembled those induced by colchicine (fig. 42). The cells, however, were little hypertrophied, which was in accord with the macroscopic findings. Four days after their return to water, the acenaphthenized-irradiated bulbs showed few, if any, aberrant changes (fig. 43). The nuclei were in resting stages. Irregularly reconstructed or lobulate nuclei were not found. The effects observed in these preparations were less strikingly aberrant than those observed in colchicinized and 1500r treated roots after their return to water for the same period.

Combined colchicine and x-rays were more injurious than either acenaphthene and x-rays or x-rays alone. The effects produced by acenaphthene and x-rays combined were little different from those changes induced by x-rays alone. From these experiments it appears that the colchicine at the concentration and with the length of exposure used has some toxic effects; which, when followed by irradiation, produce permanent changes and lead to complete growth inhibition and possibly hasten destruction. Acenaphthene induces mitotic stasis and seems to contribute little to the effect induced by x-rays.

THE EFFECT OF LONG PERIODS OF GERMINATION

It was pointed out that the onions used in the colchicine-x-ray studies described above were germinated in water from 3 to 12 days. At this time the roots had attained an average length of 3–4 cm. In the majority of experiments, the bulbs were kept in water for eight days before they were transferred to the colchicine solution. It was important to determine whether this period of germination influenced recovery from colchicine treatment. It was necessary to determine the effect of prolonged growth in water on the production of the colchicine tumors and on recovery. The effect of prolonged treatment with 0.01 per cent solution of colchicine on root-recovery was studied. The outgrowth from the hypertrophied root-tips which appeared in 24–96 hours after colchicine exposure was used as one of the criteria of recovery and viability. Forty onions of the "Yellow Globe" variety were selected at random. Their weights varied from 70 to 140 g. These bulbs were set in black-coated glass cylinders filled with tap water on Sept. 26, 1941. These bulbs were examined daily, and the cylinders were rinsed daily in hot water and refilled with cool tap water.

Bulbs 1–16 were kept in water for eight days (table 1) and then transferred to other cylinders filled with 0.01 per cent aqueous solution of colchicine. Bulbs 17–32 were grouped in pairs and kept in water for 12 days. Beginning at this time a pair of bulbs was transferred to the colchicine solution on each succeeding day until the exposure to colchicine varied from 1 to 14 days. After a given colchicine exposure, the bulbs were washed and returned to fresh water. Bulbs 33–40 inclusive were grown in water uninterruptedly during the time. The number of roots produced by each bulb was not counted but variations were observed. All the colchicine-treated bulbs produced hypertrophied root-tips. These bulbous tips varied in size in proportion to the cross section of the root-tip. The roots which were grown in water for 15–19 days before colchicine was applied formed long attenuated roots; their colchicinized root-tips were small, thin spindle-shaped swellings. When the colchicinized bulbs, 1–16, were returned to water, the resumption of growth from the bulbous tip occurred in all but two. These were bulbs 10 and 11 which were in colchicine eight and nine days respectively. In the entire series, six bulbs failed to show recovery; bulb 23 which was in water for 15 days and in colchicine for 13 days showed no outgrowth from the bulbous tip 13 days after it had been returned to water. Of the six bulbs 27–32, retained in water for 17–19 days followed by a short exposure of colchicine, three failed to resume growth. These roots appeared to be viable. While their growth activity was not measured it was apparently little. Secondary roots had already formed on these plants before they were placed in the colchicine.

TABLE 1. *Viability of roots of Allium cepa var. Yellow Globe as affected by duration in water and length of exposure to 0.01% aqueous soln. of colchicine, recovery tested by return to water.*

Bulb number	In water, days	In colchicine, days	Growth of tip resumed in water after colchicine, days
1	8	4	±16
2	8	4	± 8
3	8	5	± 6
4	8	5	± 6
5	8	6	±10
6	8	6	± 6
7	8	7	± 6
8	8	7	± 6
9	8	8	± 4
10	8	8	– 16
11	8	9	– 16
12	8	9	± 4
13	8	10	±10
14	8	10	± 7
15	8	11	± 9
16	8	11	± 8
17	12	12	± 9
18	12	12	±10
19	13	12	± 8
20	13	12	± 6
21	14	12	± 7
22	14	12	± 7
23	15	13	– 13
24	15	13	± 4
25	16	14	± 2
26	16	14	± 2
27	17	3	± 8
28	17	3	± 8
29	18	2	– 14
30	18	2	– 14
31	19	1	± 2
32	19	1	– 14

– No resumption of growth.
± Outgrowth from bulbous tip.

When plants 1–16 were discarded on Oct. 28, only bulb 12 had produced 6 leaves. The bulbs at that time were all firm and free from any visible mycotic disease. Most of the bulbs had new roots while bulb 10 was poor in that respect; its longest roots were 7 cm. and no secondary roots had been formed. Bulb 11 produced a moderate number of roots which attained a length of 15 cm. Bulbs 17 and 18 were discarded on Nov. 2. No leaves had been produced by then; the length of the greater number of their roots measured 15 cm. The remaining bulbs were discarded when they had remained 14 days in water after the colchicine exposure. The bulbs were firm and had a moderate number of roots, some of which had produced a number of secondaries. No leaves were formed. On Nov. 6, 1941, the control bulbs were firm and had no leaves. They all had long white roots with an abundance of secondary ones. The length of the greater number varied from 15 to 35 cm. The capacity of these bulbs to form roots was tested by removing all the roots and replacing them in water. A new crop of roots was formed and maintained their growth to Dec. 12, 1941, when the experiment was discontinued.

THE EFFECT OF LONG PERIODS OF COLCHICINE

In another experiment 24 bulbs of the same variety were kept in water from 8 to 28 days. Beginning with the 9th day, two bulbs were exposed to colchicine; on the 12th day two more bulbs were transferred to colchicine, and on successive alternate days the same treatment was given to two more bulbs (table 2). Those bulbs that were kept in water for a short period were given long exposures to colchicine. Long exposures to water were accompanied by short treatments in colchicine. The results showed clearly that the roots exposed to 0.01 per cent colchicine from 15 to 20 days failed to resume growth. The hypertrophied root-tips remained macroscopically unchanged. The roots, however, were not dead, for secondary roots appeared on all bulbs, from two to three days after their return to water. In the tests in which the bulbs were kept in water for 20–28 days and exposed to colchicine 2–12 days, the growth of the hypertrophied tips began in from one to three days. Bulbs 23 and 24 had long attenuated roots with small hypertrophies. The bulbous tips had apparently very little growth-power and showed only slight elongations of the tips two weeks after they had been returned to water. Secondary roots, when immersed in colchicine, formed hypertrophies too, proportionate to their diameters.

It is evident that the solution of colchicine used in the above experiments and the period of germination used before microscopical studies were made, had no effect on the viability or the growth-capacity of the roots. It is evident, too, that while colchicine inhibited growth, some toxic invisible effects were produced in addition to those which interfered with spindle formation and regular chromosome division. Exposure to colchicine for more than 12 days inhibited growth of the root. The ability to form secondary roots was not disturbed.

A study of these bulbs was made to determine the effects of 0.01 per cent aqueous solution of colchicine on the number of the roots produced during treatment and after their return to water. The number of roots was counted at four periods (table 3); at the end of eight days of germination, immediately before exposure to colchicine, immediately after exposure, and finally 14 days after return to water. The weights of the bulbs were determined before the experiment began, but the number of roots formed after the eight-day period showed that this factor influenced root-production little. Bulbs 11, 12, and 13, for instance, weighed 70 g. before exposure to water and produced 30, 65, and 70 roots respectively after eight days. Bulb 24 weighed 90 g. and produced 40 roots in the same period. Marked variations were recorded at the period before the bulbs were immersed in colchicine. Bulb 22 produced 44 roots during the first eight days, while after 26 days, before the colchicine was used, it had 101 roots. In nearly half the bulbs an increase was shown in the number of roots after the colchicine exposure. The increase in root numbers was beyond the range of error. In 13 bulbs, there

TABLE 2. *Viability of roots in Allium cepa var. Yellow Globe as affected by duration in water and length of exposure to 0.01% aqueous soln. of colchicine, recovery tested by return to water.*

Bulb number	In water, days	In colchicine, days	Growth of tip resumed in water after colchicine, days	Secondary roots formed in water after colchicine, days
2	8	20	– 14	SR + 3
3	8	20	– 14	SR + 3
4	12	18	– 14	SR + 2
5	12	18	– 14	SR + 2
7	14	17	– 14	SR + 2
8	14	17	– 14	SR + 2
10	SR 16	15	– 14	
11	SR 16	15	– 14	
12	SR 16	15	– 14	
13	SR 18	14	+ 4	
14	SR 18	14	– 14	
15	SR 20	12	– 14	
16	SR 20	12	± 3	
17	22	10	± 3	SR + 2
18	22	10	± 3	SR + 2
19	SR 24	6	± 1	
20	SR 24	6	± 4	
21	SR 26	4	± 3	
22	SR 26	4	± 4	
23	SR 28	2	± 14	
24	SR 28	2	± 14	

+ Elongation of bulbous root tip.
± Outgrowth from bulbous tip.
– No recovery.

was no change or a slight decrease in the number of roots. On bulbs 8, 15, 16, and 21 there was a considerable decrease in the number of roots. This may be attributed to the death of the root followed by complete disintegration due to other factors and not to colchicine only. The count made 14 days after the bulbs were returned to water showed some variation; eight bulbs showed an increase in the number of roots formed. An actual number of

TABLE 3. *The effect of 0.01% aqueous soln. of colchicine on the number of roots of Allium cepa var. Yellow Globe.*
N—new T—turgid F—flaccid Fx—fixed

Bulb number	Number of roots							
	In water		In colchicine	14 days in water after colchicine	Analysis			
					N	T	F	Fx
days	8		20					
1	39		66	59	2	45	6	6
2	37		43	41	8	20	12	1
3	26		52	63	4	55	2	2
days	8	12	18					
4	40	40	40	48	13	22	9	4
5	43	43	58	46	5	37	4	0
days	8	14	17					
7	39	44	58	57	2	40	13	2
8	25	43	33	50	15	32	3	1
days	8	16	16					
10	30	40	46	52	0	29	21	2
11	30	37	37	37	3	31	2	1
12	65	93	93	93	0	60	26	6
days		18	14					
13		70	68	76	2	65	8	1
14		67	95	79	4	67	8	1
days		20	12					
15		56	38	38	6	17	15	0
16		38	31	28	0	22	6	0
days	8	22	10					
17	40	47	49	61	17	38	6	0
18	28	48	52	43	9	29	3	2
days	8	24	6					
19	22	54	56	66	15	48	2	1
20	66	95	97	90	3	70	12	5
days	8	26	4					
21	55	58	51	59	12	26	15	6
22	44	101	102	96	0	74	19	3
days	8	28	2					
23	48	62	62	64	7	46	8	3
24	40	78	78	66	18	37	9	2

viable roots would include the new roots, the turgid long roots, and those fixed for microscopic examination. The number of flaccid, water-soaked roots varied from 2 to 26 roots per bulb. The number of new roots formed varied from 2 to 18. It was clear that the long exposure of the roots to water with short exposure to colchicine had no more effect on the number of roots produced than long exposures in colchicine coupled with short exposures to water. The number of roots produced by a bulb is probably a genetic factor.

TABLE 4. *Viability of roots of Allium cepa as affected by duration of exposure to 0.01% aqueous soln. of colchicine followed by x-rays and return to water.*
Bulbs were grown in water for 8 days before treatments began.

Bulb number	In colchicine, hours	Secondary root formation, days	Growth from bulbous tip in water after colchicine, days
Group A 1500r var. Yellow Globe			
25	18	23	+ 25
26	18		+ 21
27	18	18	+ 21
28	18		+ 21
29	18		+ 21
no xr 30	18	8	± 21
no xr 31	18	10	± 24
Group B 1500r var. Yellow Globe			
33	36		+ 25
34	36		–
35	36		+ 21
36	36		+ 21
37	36		+ 21
no xr 38	36	20	± 21
no xr 39	36	20	± 21
Group A 1500r var. Brigham Yellow Globe			
1	48		E –
2	48		–
3	48		E –
4	48		–
6	48		–
no xr 18	48	4	± 3
Group B 3000r var. Brigham Yellow Globe			
7	48		–
8	48		–
9	48		–
11	48		–
12	48		–
no xr 14	48	4	± 3

+ Slight extension of root from bulbous tip.
± Continued outgrowth of root from bulbous tip.
– No outgrowth from bulbous root-tip, 30 days.
E Extension and elongation of root tips.

Colchicine, in the concentration used, inhibits growth, and water restores this growth ability.

VIABILITY OF ROOTS AFTER COLCHICINE AND X-RAYS

The roots of the "Yellow Globe" and the "Brigham Yellow Globe" varieties were also studied as to their ability to recover from the colchicine and x-ray treatments. The bulbs were germinated for eight days and then exposed for 18, 36, or 48 hours to colchicine, which was followed by an exposure of 1500r or 3000r (see table 4). The "Yellow Globe" exposed for 18 and 36 hours showed some limited growth of bulbous root-tips, while the non-x-rayed bulbs showed more extensive growth after their return to water. The "Brigham Yellow Globe" exposed to colchicine for 48 hours showed some slight extensions or elongation of the bulbous tips after an exposure to x-irradiation of 1500r but no growth or elongation was noted after 3000r exposure. These observations were made 30 days after their return to water.

TABLE 5. *The number and length of roots of Allium cepa var. Yellow Globe before and after exposure to 0.01% aqueous soln. of colchicine and x-rays. The bulbs were placed in water on 11.3.41. Group A was exposed to colchicine on 11.11.41 for 18 hours; irradiated on 11.12.41 and returned to water. Group B was exposed to colchicine on 11.11.41 for 36 hours; irradiated on 11.13.41 and returned to water.*

c^1—colchicine—18 hours c^2—colchicine—36 hours x—irradiation 1500r 11 min.
T—turgid F—flaccid Fx—fixed

Bulb number treatment	Number of roots					Maximum length of roots		
	8 days in water, cm.	8 days after colchicine and irradiation, cm.	27 days after colchicine and irradiation, cm. T	F	Fx	After colchicine, before iradiation, cm.	22 days after colchicine and irradiation, cm.	30 days after colchicine and irradiation, cm.
Group A								
6x	35	42	33	9	7	14.5	12	13.5
32x	44	36	48	10	13	11	11	11
$25c^1x$	37	53	64	3	3	11	12	16
$26c^1x$	26	27	36	4	2	11.5	10	9
$27c^1x$	35	67	44	4	8	15.5	16	16
$28c^1x$	47	55	60	2	12	12	13	15
$29c^1x$	33	33	39	4	4	14.5	13	14
$30c^1$	36	49	37	8	5	13.5	18	19.5
$31c^1$	34	46	89	2	5	11	19	20
Group B		7 days	26 days				21 days	29 days
9x	35	27	33	7	18	13	15	15
40x	66	81	67	6	14	19	20	18
$33c^2x$	72	71	80	9	7	12.5	12	13
$34c^2x$	25	18	15	4	5	15.5	16	16
$35c^2x$	23	25	29	4	2	13	13	13
$36c^2x$	57	59	44	3	7	13	12	13.5
$37c^2x$	79	69	58	11	12	9	10	11
$38c^2$	75	104	98	17	6	13	15	20
$39c^2$	33	36	49	4	3	11	23	28

A study was made of the number and maximum length of roots in the "Yellow Globe" and "Brigham Yellow Globe" varieties. These results are tabulated in tables 5 and 6. On bulbs 6x and 32x (table 5, Group A) irradiated only with 1500r the longest roots did not increase in length, but the number of roots increased. The colchicine and irradiated group, $25c^1x$–$29c^1x$, recovered temporarily; the new outgrowths were small, most of them measuring 0.5 cm. or less. The bulbs $30c^1$ and $31c^1$ treated with colchicine showed greater increase in length and number of roots. The inhibiting influence of the combined effects of colchicine and x-rays was not entirely overcome even after 30 days in water.

TABLE 6. *The number and length of roots of Allium cepa var. Brigham Yellow Globe before and after exposure to 0.01% aqueous soln. of colchicine and x-rays. The bulbs were placed in water on 12.19.41; exposed to colchicine on 12.27.41; irradiated on 12.29.41 and returned to water.*

c—colchicine—48 hours x¹—irradiation 1500r—15 min. x²—irradiation 3000r—30 min.

T—turgid F—flaccid Fx—fixed

Bulb number, treatment	Number of roots				Maximum length of roots				
	8 days in water	21 days after treatment T	F	Fx	8 days in water	2 days after colchicine, before irradiation, cm.	4 days after irradiation, cm.	12 days after irradiation, cm.	19 days after irradiation, cm.
$1cx^1$	43	39	0	3	11	11	12	10	10
$2cx^1$	55	37	15	7	10	11	11	11.5	11.5
$3cx^1$	62	40	4	7	9	10.5	10.5	9.5	10
$4cx^1$	59	52	10	10	13	14	14	13.5	14
$6cx^1$	24	14	8	2	13.5	15	14	12.5	11.5
$5x^1$	23	36	0	8	11	13.5	16	15	12
$16x^1$	23	33	7	7	10	13.5	13	12	13
$7cx^2$	61	25	30	3	13	12.5	14	13	14
$8cx^2$	31	29	14	3	14	14	15	11	11
$9cx^2$	66	34	9	20	13	14	13	12	12
$11cx^2$	62	32	14	7	10	11	11	11	11
$12cx^3$	59				10	10			. .
$13x^2$	44	14	18	7	10	13	10	10	10
$17x^2$	24	29	6	7	13	15	10	11	10
14c	40	46	8	8	12	14	15	18	18
18c	46	60	0	7	14	14	14.5	17	17
10	11				12	12	10.5	12	
15	16	24	5	0	11.5	14	18	16	19

In Group B, $33c^2x$–$37c^2x$, in which the colchicine treatment lasted 36 hours and was followed by x-irradiation with 1500r, the number of roots increased slightly while the length of the largest roots increased little. On bulbs 9x and 40x, 26 days after their return to water, the number and length of roots increased. The bulbs treated with colchicine only ($38c^2$ and $39c^2$), however, showed the largest increase in number and length of roots.

Colchicine treatments which lasted 48 hours and were followed by irradiation of 1500r and 3000r were also studied and recorded in table 6. There was a slight diminution in the number of roots after the treatment with colchicine and with the higher dosage of x-rays. There appeared also to be a large number of flaccid roots in this group. Bulbs irradiated only, $5x^1$ and $16x^1$, gained in number of roots, while $13x^2$ showed a slight decrease in the total number of roots present and bulb $17x^2$ showed a gain. The colchicinized bulbs 14c, 18c, gained in root number and root length. The roots of bulbs treated with colchicine and x-rays combined measured slightly less in length than the roots of the bulbs irradiated only. The latter gained slightly in the 19-day period over the 12-day period, while with the large dosage of x-rays used, no increased growth was evident. This colchicine-x-ray group lost length. In the above studies the loss in average length of root was due to the fact that the long roots, apparently the older ones, which were used as a basis for comparison, were the first to die. It seemed that the length and number of roots of bulbs treated with colchicine for 48 hours followed by irradiation with 3000r were impaired more by this treatment than by the x-rays alone.

SUMMARY AND CONCLUSIONS

1. The above report deals with the combined effect of a 0.01 per cent aqueous solution of colchicine and x-irradiation on the root-tips of *Allium cepa*, varieties "Yellow Globe" "Brigham Yellow Globe."

2. Fifteen series of experiments were made, each using from 6 to 40 bulbs.

3. The gross effects of this solution of colchicine on the root-tips of these bulbs were studied and compared with microscopic examinations after periods of exposure varying from 6 to 200 hours.

4. The root-tips of onion bulbs were studied in the gross and microscopically especially after 18, 24, 36, 48, 72, and 120 hours of exposure to colchicine of a constant concentration followed by exposures to one of three doses of x-rays, 900r, 1500r, and 3000r. The combined effect was studied shortly after irradiation and at various periods after the return of the bulbs to water. Untreated colchicinized bulbs, and bulbs x-rayed only, were used as controls and studied concurrently in each series of experiments.

5. The effect of colchicine exposures for more than 48 hours followed by irradiation of 900r prevented growth of the root-tip; 48-hour exposure to colchicine with 1500r induced similar results. Exposures of 48 hours combined with 3000r prevented further growth of the root-tip. With the shorter exposures to colchicine, 18, 24, 36 hours, and 1500r, the hypertrophied tips produced only a limited growth which became arrested from five to seven days after their return to water.

6. Irradiation with 900r, 1500r or 3000r impaired growth; the time for recovery was less than that required for the combined effect of colchicine and x-rays.

7. A study of length and number of roots of the bulbs treated with colchicine for 18, 36, 48 hours followed by irradiations of 1500r or 3000r was made. The viability of the roots was tested by returning them to water. Root-tips treated with colchicine alone resumed growth in from 72 to 96 hours. Those irradiated only resumed growth more slowly. The colchicine-x-rayed roots failed to resume growth.

8. Exposure of the roots to the colchicine solution for 28 days appeared only slightly toxic. The hypertrophies of the root-tip when returned to water still showed evidence of recovery by new growth from the small bulbous tips. Roots grown in water for long periods and exposed for from 24 to 48 hours in colchicine reacted with hypertrophies proportional to the area of the cross section of the root-tip.

9. Cytological studies of the root-tips were made of normal untreated roots from 3 to 12 days after exposure to water; from 6 to 200 hours after exposure to colchicine; and after various periods which began immediately before their return to water and continued to 14 days after the colchicine and x-ray exposures were made. Root-tips irradiated only were fixed before and after the treatment. The fixations began from one to two hours after irradiation and at daily intervals thereafter up to 14 days. The cytological observations on these root-tips after colchicine combined with x-rays were consistent with the measurements made on root number and root lengths. These root-tips showed slower recovery as evidenced by fewer divisions found in these roots as compared with those x-rayed only.

10. The cytological phenomena which immediately resulted from the colchicine-x-ray treatments were more intensified clumping, fragmentation, and extrusion of chromosomes. There appeared to be some visible effects on the resting nuclei in that the chromatic material was distributed near the nuclear membrane leaving a clear area about the nucleoli. Twenty-four hours after irradiation, no division stages were found. Three or four days after the treatment, the cells irradiated only began to divide, while those that received the colchicine and x-rays combined showed few nuclear divisions. The nuclei became homogeneously stained; the meristem was interspersed with many highly vacuolated cells.

11. These cytological studies do not favor the view that the greatest number of cellular injuries occurred when irradiations were made at the time when the metaphase stages were most abundant. The colchicine appeared to sensitize the cells to x-rays at the time when nuclear reconstruction began, which occurred about 48 hours after the exposure to colchicine was started.

12. Onion roots covered with crystals of acenaphthene and exposed to a saturated solution of this chemical produced only small hypertrophies after 48 hours and little or no gross visible changes after shorter exposures. The effects on nuclear and cell divisions, however, appeared similar to those pro-

duced by colchicine. The combination of acenaphthene and x-rays in which 900r, 1500r, and 3000r were used followed closely the results obtained with x-rays alone.

13. "Colchicine tumors" are not analogous to animal neoplasia or plant overgrowths induced by bacteria or growth substances.

14. The combination of an exposure of 900r and a treatment with 0.01 per cent aqueous solution of colchicine for less than 72 hours, or 1500r and 48 hours of colchicine, are most effective in arresting growth of fundamental plant tissues such as the root-tip of the onion.

15. It is suggested that more intensive studies be made with this drug combined with x-rays on tumors of animals and man. The fact that some animal tumors and simple but normal plant structures show delayed growth after such treatment makes it necessary to obtain suitable concentration of colchicine followed by a selective dose of x-rays which will tend to inhibit and to destroy cancerous tissue without interfering with normal life processes of the host.

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REMARKS UPON CERTAIN HAWAIIAN LABIATAE AND COMPOSITAE

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In a recent issue of this magazine (**72**: 25–30. 1945), there appeared from St. John's pen a contribution touching in great part upon certain Labiatae and Compositae that had been treated previously by me. Various assertions, these sometimes direct and sometimes by implication or innuendo, were made touching my monographic studies of Hawaiian plants. For thirty years (but more intensively for the past fifteen) I have taken an active interest in these monographic studies and have produced from time to time papers detailing their results. It now appears advisable, therefore, to set forth for future users of these results a somewhat detailed reply to Dr. St. John's paper. This indeed seems imperative in view especially of such words as: "the now numerous, hurried revisions of Hawaiian genera by Sherff. These treatments and keys have proven to be the despair of students of the Hawaiian flora." That these revisions are now numerous must perhaps be admitted, but is due in large part to the almost unparalleled cooperation of botanists and botanical institutions in Europe, the United States, and the Hawaiian Islands. The important specimens by Hillebrand, Gaudichaud, Nuttall, Beechey, Chamisso, Rock, Faurie, Forbes, Degener, and practically all other collectors of Hawaiian plants were placed at my disposal, often for as much as from three to six years.[1] To say that St. John is warranted in terming these revisions "hurried," however, would seem to imply considerable intimacy on his part with the conditions under which the work was carried on. This is the more surprising when we consider that much of the time since 1929, when he first took up residence in the Hawaiian Islands, he has been removed several thousand miles from Chicago, the seat of my botanical activity. It seems preferable to believe, rather, that he has found himself vexed by the inadequacy of some of these revisions (surely some cannot be otherwise until our herbaria become more richly supplied with specimens) and accordingly used the first word that came to mind. It may be insisted before going further, however, that the revisions were never "hurried." Fortunately, all of my Hawaiian researches have been privately conducted on my own time, with no compulsion or inducement from any outside source whatever to do a "hurried" piece of work. Consequently, any matters observed or assumed by St. John to merit criticism in the finished product should be otherwise explained. Certain such matters will now be noticed.

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[1] As illustrative of this cooperation, more than twenty-five years ago Charles N. Forbes and his associates at the Bishop Museum in Honolulu assembled and sent to me a vast collection of Hawaiian *Bidens* material, in which ten new species were found (cf. Field Mus. Bot. Ser. **16**: 11. 1937).

LABIATAE

Under the new combination *Stenogyne mollis* (Sherff) St. John, is given (p. 25) a discussion of the predecessor name *S. rugosa* var. *mollis* Sherff. Reasons are stated for elevating the variety to specific rank. Reasons for not doing so are omitted. To properly understand any of the latter that may exist, it should be remembered that the Hawaiian Islands are geographically much isolated and in turn abound in individual, often very small localities of great isolation. There is remarkable endemism. Many of the species studied by competent monographers have been found to have numerous varieties. Ofttimes these varieties, if viewed separately, will appear to be distinct species and indeed may differ mutually more than do some generally recognized species elsewhere. When all are assembled side by side, however, they are seen to form a very logical species-complex ("Formkreis"). It actually happens that in some cases important supravening, connecting links seem to have vanished in recent years from the Hawaiian flora; at least they have not been found for many decades and are known today only through herbarium specimens (*Euphorbia Remyi* A. Gray ex Boiss., the species proper, and *E. multiformis* H. & A., the species proper, being examples). One becomes sorely tempted to relegate such links to the realm of paleobotany, and proceed with a fresh delimitation of species. He can seldom be sure, however, but what one or more of the lost (or shall we say missing) links will yet be found to have escaped destruction and to have reappeared to press its claims. In my own revisions of Hawaiian plants, I have chosen always to base specific and varietal concepts, therefore, upon the fullest assortment of specimens to be had, regardless of whether or not they represented entities known to be still living.

To return to *Stenogyne rugosa:* After making virtually a monographic study of *Stenogyne* many years ago, Asa Gray (Proc. Am. Acad. **5**: 348. 1862) wrote of this species: "Variat. 1. fere omnino (corolla excepta) glaberrima, laevis, seu pedicellis calycibusque hirsutulis: 2. hirsutula vel hispidula, foliis nunc rugosis asperulis: 3. pube brevi molli induta, verticillastris 6–10-floris." It is the third form that was the basis of my var. *mollis*. The second form was referred by me (op. cit. 66) to *S. rugosa* proper. It was because of this somewhat intermediate[2] form's existence that I preferred to treat the third form not as a distinct species, but rather as a variety of *S. rugosa*, namely var. *mollis*.[3]

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[2] Intermediate as to pubescence.

[3] Certain characters (of uniformity of pubescence, of calyx-lobe length and shape,

Under *Stenogyne rugosa* Benth., St. John places as synonyms *S. rugosa* var. *subulata* Sherff and *S. kaalae* var. *coriacea* Degener & Sherff, following these with a discussion. My own discussion now follows. In 1872, Wawra described *S. kaalae* (Flora **55**: 556), although Thomas Nuttall had long before collected it on Oahu and given it the unpublished name, *Phaeopsis montana* (a specimen in Herb. Kew; cf. Benth. in DC. Prodr. **12**: 556. 1848, nom. nud.). Hillebrand accepted Wawra's species, and rightly so. Among other characters noted for it was the very exceptional one that the pedicels, when several at a node, were "often joined in a short common peduncle." Until the recent description by Degener of *Stenogyne Sherffii* (Brittonia **5**: 58, *fig. 1.* 1943), *S. kaalae* was the only species of *Stenogyne* known with this character. In the sister genus *Phyllostegia* previously monographed by me (Bull. Bish. Mus. **136**: 12–59. 1935), only the one species *P. glabra*, together with its varieties, was known with a like character (although recently a second such species has been described, namely *P. Yamaguchii* Hos. & Deg., Occas. Papers Bish. Mus. **14**: 27–29, *fig. 1.* 1938). Somewhat prior to 1935, two suites of *Stenogyne* specimens, *Degener 5371* and *5389*, were studied and found to display the axillary peduncles previously known in *Stenogyne* only for *S. kaalae*. These were then named *S. kaalae* var. *coriacea* Degener & Sherff. In my monograph I cited a lone herbarium for each suite since the rest of the specimens had not yet been distributed by Degener to other herbaria. In the place of official publication (Deg. Fl. Haw. Isls. Sept. 13, 1935), however, it was stated that duplicates were "in the Degener Herbarium, in that of the New York Botanical Garden, and in several other leading herbaria in America and Europe."[4] Hence it can be seen that there was more than pure caprice of fancy to dictate our treatment of the two Degener suites as a variety of *S. kaalae*.

In making his interpretation of var. *coriacea*, St. John apparently overlooks not only the importance of the *frequently pedunculate inflorescence* character but also the fact, clearly indicated long ago by Hillebrand and later by myself, that the number of flowers per whorl is not constant. Thus Hillebrand wrote: "Verticillasters or whorls *generally* [italics mine] 2-flowered" versus "whorls *generally* [italics mine] 6-, but also 4-, 8-, or 10-

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etc.) stressed by St. John for his *Stenogyne mollis* fail badly on extended examination of specimens.

It is interesting to note that as recently as 1943, Skottsberg, writing on Dr. Sven Berggren's collection of Hawaiian Vascular Plants (Bot. Notis. **1943**: 368), retained my *mollis* as a variety and described under it a new forma *mollissima*. Moreover, a plant collected by himself (his no. 621) and previously cited by me for the var. *mollis*, was described by him (doubtless from a *duplicate* of the specimen actually studied by me) as "more like ordinary rugosa" in the "texture of leaf and size of corolla."

[4] Unfortunately the artist who delineated the sketch for Degener's Flora Hawaiiensis did not bring out the peduncles clearly, although he did show one very clearly on his original draft.

flowered."[5] Early in my study of *Stenogyne* it seemed that a key might be improved by avoiding such a basis of separation, because of its lack of sharpness. As the investigation proceeded, however, it became obvious that Hillebrand's method was probably as sound as would be found in the present state of our knowledge. Accordingly it was adopted.[6]

St. John's reduction of my *Stenogyne rugosa* var. *subulata* to *S. rugosa* may be considered here for the moment. *S. rugosa* was described by Bentham (Bot. Reg. sub *pl. 1292*, Tribo 6, num. 88. 1830) from Macrae's plant (Kew) and the calyces were said to be acutely dentate ("calycibus aridis acute dentatis"). Bentham later (in DC. Prodr. **12**: 556. 1848) had seen an additional plant by Menzies and rewritten his description of the calyces to read, "4–5 lin. longi, dentibus ovato-lanceolatis obtusis, 2 infimis brevioribus sed profundius fissis." He added that the leaves were oblong ("foliis . . . oblongis"). Hillebrand (Fl. Haw. Isls. 355. 1888) excluded *S. rugosa* from the portion of his key beginning "Calycine lobes linear or subulate" but placed it rather under the portion beginning "Calycine lobes not linear." Hillebrand described (op. cit. 356) the leaves as "ovate to ovate-lanceolate" and recorded that the trailing branches bore narrower leaves than did the erect ones. In my monograph (p. 66) I likewise described the leaves as "ovate to ovate-lanceolate." The calycine lobes I called "more or less lanceolate" and "acute." They should perhaps be described as "obtuse to acute" for some are indeed too broad to rank as acute. St. John finds fault with my key to the varieties and ends, as already stated, with reducing var. *subulata* to synonymy with the species proper. Unfortunately he limits his basis of study to certain specimens which I had cited for each entity. Not all of the material cited by me for *S. rugosa* and the var. *subulata* is now accessible but most of the specimens reexamined separate readily enough if more attention is paid to the shape of the calyx-lobes, these tending to be, for var. *subulata,* not only "mostly exceeding the tube" (as stated in my key) but narrower and, at least above, "very sharply subulate" (as pointed out in my description). It seems probable that I erred in my monograph in referring some material (e.g., *Degener 5393*) to the species proper instead of to the variety *subulata,* thus confusing the situation all unintentionally for St. John. (It may be pointed out that St. John's study was not said to be a field-study but rather a reexamination of some specimens that had been cited by me.) It is to be hoped that other students may study the two forms in the field to see if indeed they are inseparable as stated by him.

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[5] Under the first alternative he keyed *S. kaalae* and under the second, *S. rugosa*. Unfortunately, the peduncle often visible in *S. kaalae* and its variety can be noticed of course only in the cases that depart from the more common ones by having 4 or even 6 flowers per whorl.

[6] At one point (p. 29), St. John expands upon the art of making keys. We read: "The making of keys is an art, well mastered by some botanists but not by others. The excellence of the key is a good test of the finished quality of taxonomic work." Experienced monographers will of course not be deceived by the underlying innuendo of such lines. Generally speaking, "excellence of the key" is easy to secure for simpler and better understood genera and often difficult for the others. Moreover, it must be borne in mind that many of the genera monographed by me for the Hawaiian Islands were considered "the most difficult and intricate Hawaiian genera" by no less an authority than Otto Degener (Brittonia 5: 58. 1943). Indeed, some of them (*Euphorbia*, *Labordia*, *Pittosporum*, etc.) had been persistently shunned by other workers because of the apparently insuperable difficulties involved. It would seem then that any dissertation, however brief, upon the subject of keys might well include additional considerations. We may charitably suppose that such considerations never occurred to St. John's mind. At all events, the difficulties encountered in certain of my keys to the more "difficult and intricate Hawaiian genera" were of necessity present, and at times to a greater degree, in earlier keys by such pioneers as Asa Gray and William Hillebrand. It seems too bad that these great men, long since dead and unable to utter a word in their own defense, must be thought of to-day as within the scope of St. John's censure.

COMPOSITAE

St. John discusses my treatment (Bull. Bish. Mus. **135**: 83–108. 1935) of of the genus *Dubautia* Gaud., particularly that of *D. plantaginea* and my variety of it, var. *Chamissonis.* He adduces what to him seem reasons for construing var. *Chamissonis* as synonymous with the species proper and forthwith equates the two. In the same paragraph, however, he renames the species proper, in its varietal sense, "var. *typica* St. John var. nov." If it be assumed that my var. *Chamissonis* was indeed the typical *D. plantaginea,* it is difficult to understand his inventing the new name *typica* for the variety already validly named *Chamissonis.* It is especially difficult since on an earlier page in the same paper (p. 22) St. John assures us all that "today we do taxonomic work in conformity with the detailed articles and recommendations of the International Rules of Botanical Nomenclature." Nowhere do the International Rules permit such random replacement of once validly published names for any status.[7]

A reexamination of the herbarium evidence, together with a painstaking reading of St. John's discussion, leaves me entirely unconvinced, however, that he has proved his case against var. *Chamissonis* as a variety apart from typical *D. plantaginea.* (1) I had said that *D. plantaginea* proper was "known only from the island of Lanai." St. John remarked, speaking of the voyage on which the type of the species itself had been collected, that "the Urania Voyage did not visit Lanai, so Gaudichaud could not have collected a species restricted to the mountains of the island." There was no warrant for his use of the word "restricted." As all advanced workers on the Hawaiian flora are aware, a certain proportion, not large to be sure, of the species or varieties found on Lanai are not "restricted" to that island but occur on one or more of the other Hawaiian Islands. Many of these entities are of very local distribution and with the advent of increased population, introduction of domestic animals, etc., are exterminated on one or more of the islands. *D. plantaginea* proper is doubtless an example of this. Anyway, since Gaudichaud did not tell from which island his type had come and since the only more or less matching material available today was collected on Lanai, I could not well have cited the "known" present-day distribution differently.[8] (2) St. John refers to the only two collections (*Munro 48* and *Munro 271*) that I had cited for *D. plantaginea* in addition to the original type collection by Gaudichaud and stresses that they show traces of disease and injury. His implication seems to be that the distinguishing alternate (or in one case "subopposite") arrangement of the principal (i.e., lowermost) branches of the infloresence is teratological. I have before me, however, a large photograph (my negative no. 2756) of an original Gaudichaud specimen (in Herb. Berl. and formerly studied by me) and this has the infloresence with definitely alternate principal branches as portrayed in Gaudichaud's type plate, *but shows no evidence whatever of injury or disease.*[9] The fact, therefore, that modern Lanai material, even though somewhat teratological in its somatic tissues, exhibits the unique alternate arrangement observed originally in the Gaudichaud type collection, would seem to connote more than trivial value for this character. Nor in all the cited material of my var. *Chamissonis, several specimens of which had been affected likewise by injury or disease,* did I find any specimens where the principal branches of the infloresence had been induced to depart from their opposite or essentially opposite arrangement. (3) St. John cites (p. 27) an apparent "oversight" on my part in my omission of Lanai as one of the islands on which var. *Chamissonis* grows, although I cited specimens for that island; also (p. 28) my including Kauai, Maui, and Hawaii in my "carelessly handled" statement of "geographic range" when no specimens from those islands were cited. My revision of *Dubautia* was published, it may be observed, by the Bishop Museum in remote Honolulu and a number of such errors crept into the final text as it was going through the press and being considerably overhauled at Honolulu to adapt it more exactly to the Bishop Museum's preferred style. Several very definite alterations in arrangement of text were made by the editorial assistants (such as shifting the "Distribution" paragraph to the end of the respective treatment), thus increasing the liability for error. I was afforded no opportunity to recheck the final page proof. It would seem, therefore, that St. John, himself a botanist and botanical adviser in editorial matters at Bishop Museum (even at the time my monograph was being dissected and "edited"), would be exceedingly cautious about attributing such errors to the author's own carelessness. However, in the ten years that have since elapsed, I have noted in my privately annotated copy all such errors as soon as detected. It is planned to publish a list of such *errata* later on. All additions to this list, from whatever source, will be welcomed. (4) In my monographic treatment of *Daubautia*, as the reader may have inferred, I separated var. *Chamissonis* as having "principal branches of panicle opposite" and *D. plantaginea* proper as having "principal branches of panicle alternate." I had seen several specimens of the former in which, at one or two lower nodes of the inflorescence's axis, one of two opposite branches had been stunted or actually broken off (although both of the subtending leafy bracts remained!), giving very superficially a slight semblance of alternate branching. St. John cites five collections having "the lower one to three nodes producing alternate branches." Since three of his five cited collections (*Fosberg 9007*, *Fosberg 10363*, and *Garber 140*) had been carefully studied by me (the two *Fosberg* numbers are now before me) and been found to be illustrative of this trifling departure, I cannot be seriously impressed with his reasoning. Surely his conclusion (p. 28) that alternate branching of the inflorescence "does not appear significant" will need much better evidence than he has offered.[10]

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[7] The wisdom or unwisdom of establishing a fresh varietal name such as *typica,* as in this case, is not here under discussion. In the name of consistency, however, it does seem only fair that avowed devotees of the International Rules note concisely and openly those provisions of the Rules that they refuse to accept.

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[8] Skottsberg, in a paper not cited by St. John (Meddel. Göteborgs Bot. 15: 508. 1943), rejected my var. *Chamissonis* partly because of reasoning akin to St. John's regarding Lanai, and partly because of having found some specimens (*Skottsberg 3686*) where the branches of the second pair were alternate. Touching this latter consideration, it need hardly be observed that a vast proportion of generally recognized varieties among vascular plants would have to be discarded if the existence of an occasional intergradation were to be accepted as the guiding criterion.

[9] Cf. Skottsberg (Meddel. Göteborgs Bot. Trädgård 2: 276. 1926). Skottsberg had studied this Berlin specimen. He wrote: "According to Gaudichaud the branches of the panicle are alternate, and so they are in this specimen which is, however, rather exceptional in this character." It will be noted that Skottsberg recorded no impression or suspicion that any injury or other teratological effect was involved.

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[10] It may be remarked that here (to judge from the three cited specimens seen by me) he has seized upon abnormalities of development in var. *Chamissonis*, these at times emphatically teratological, to justify a synonymizing of var. *Chamissonis* with typical *D. plantaginea*. And yet on an earlier page (p. 27), as we have already noted, he has sought to explain away the value of alternate principal (i.e., lowermost) branches of the inflorescence on the two modern specimens of *D. plantaginea* cited by me for Lanai, by stating that they had "injured main stems, and reduced panicles produced on the weak secondary branchlets." *Thus teratology or mere accidental injury, as the case may be, is now to be welcomed, now to be abhorred in the evaluation of diagnostic criteria.* But the case is less hopeless than it might seem, for St. John does admit the reliability of Gaudichaud's full-page plates. He says: "On gross detail they are excellent." He concludes that Gaudichaud was portraying a full-sized inflorescence, not one "from weak secondary branchlets, as in the two cited by Sherff." Of course, Sherff cited the only two modern specimens known to him as seeming to match the species proper, and was in no way to be blamed for their collector's having selected the somewhat injured sprays that he did. But even if we exclude these two plants by Munro from consideration, the handsome Gaudichaud plate and the Berlin specimen above referred to, both with all branches of the inflorescence *and their subtending bracts* regularly spaced in alternate arrangement, can in no way be said to show teratology, so there seems little point to much that St. John says.

(5) St. John follows his attack upon my treatment of *Dubautia plantaginea* with a further paragraph (p. 28): "The only remaining differences mentioned by Sherff are: *D. plantaginea* having the leaves 'at base more or less widened and clasping the stem'; var. *Chamissonis* having the leaves 'more or less narrowed toward base and semiamplexicaulous.' This sounds like the recognition of a broad leaved and a narrow leaved variant. Close study of the many cited specimens and of others shows no difference whatever. The qualifying phrase 'more or less' seems to make the words widened and narrowed, quite meaningless, as used by Sherff." It is difficult to understand how any competent taxonomist could fail to note at once the broader bases of the principal leaves on *D. plantaginea* proper. Indeed, Asa Gray (Proc. Am. Acad. **5**: 135. 1861) criticized Gaudichaud's plate of *D. plantaginea* proper for having the leaves "much too broad at the base." That was perhaps a pardonable error for Gray to make in his day, since the specimens in herbaria at his time were almost exclusively the ones with narrower leaf-bases and later separated by me as var. *Chamissonis.* In an effort, however, to learn if possible what basis might exist for St. John's criticism, I have reexamined all available material of var. *Chamissonis.* I find that this variety occasionally has a stunted shoot with the leaves crowded together at the base of a flowering branch or at the end of a sterile branch. In such cases the leaves may have broad bases. On flowering branches of normal development, however, i.e., with average-length internodes among the leaves, the leaf-bases are commonly narrow.

St. John cites the portion of my key in which *D. plantaginea* and its var. *Chamissonis* are separated from the var. *angustifolia*, once described by me. He then remarks: "Neither a first nor a repeated reading of those lines will reveal any tangible key characters. A key should single out diagnostic differences, but this one fails to do so." Much will depend, I fear, upon who reads the key. It must be emphasized that the cited key was written seriously for sincerely minded botanical workers and went as far in its characterizations as the facts at hand and the state of our knowledge of the genus at that time seemed to warrant. To quote a portion of the text repeated by St. John:

"a. Principal leaves . . . commonly 1–3.4 cm. wide. . . .
a. Principal leaves . . . 0.7–1.3 (rarely – 1.6) cm. wide . . . var. γ angustifolia."

It seems to the present writer that any unbiased student would deem 1.3 or even 1.6 cm. maximum width for the leaves a tangible key character as against 3.4 cm. Unfortunately one specimen (*Fosberg & Duker 8795*) cited by me for var. *angustifolia* had the larger leaves and doubtless should have been referred to var. *Chamissonis.* But the other cited specimens were definitely narrow-leaved. It happened that for the var. *anguustifolia* I had to rely more often upon a single specimen of any one collection, rather than upon a large suite of specimens (sometimes totaling 30 or 40 or more in the case of plants collected by Otto Degener and his associates). There was thus less opportunity to study a range of leaf-width variations. It is my present judgment, however, after a reexamination of the present collection at the Chicago Natural History Museum (including large photographs of several specimens previously cited by me from elsewhere), that var. *angustifolia* will probably stand as a good variety. This despite St. John's reduction of it, as of var. *Chamissonis*, to synonymy with *D. plantaginea*. We may note in passing that St. John (p. 29) makes much of my words for var. *angustifolia*, "bracts (leaves) more elongate" and denies that this is so. Reference to my original description of the variety (Am. Jour. Bot. **20**: 616. 1933) shows that these four words were absent, as they rightly should have been. How they came to be inserted in my monograph when it was printed by Bishop Museum I do not know. They are of course wrong and I cannot believe that they were a part of my own manuscript, long since destroyed. We may note, further, that St. John (p. 29) complains that "var. *angustifolia* has no distinct geographic range." In the Hawaiian Islands, endemism is many times pronounced and there result many separate, restricted geographic ranges. A study of ranges thus becomes a major consideration in the delimitation of new taxonomic entities. It has always played an important part in my own studies of Hawaiian genera. It is not, however, the only consideration, nor even the greatest. Morphology is after all more important and unless subsequent study by other observers reveals a noteworthy inconstancy in the narrow-leaved character for var. *angustifolia*, the variety's status as such surely will have been vindicated. At this point it may be remarked that while my cited material of var. *angustifolia* consisted mostly of unicates, my cited material of var. *Chamissonis* (with which St. John equates it for the moment) included several, often large suites of specimens (e.g., *Degener 4325*, 7 specimens; *Degener 4333*, 12 specimens; *Degener 4337*, 4 specimens; *Degener & Park 4338*, 2 specimens; *Degener & Park 4342*, 9 specimens). In these suites (numerous additional specimens of which were left uncited by me and returned to Degener for later distribution with his other exsiccatae to various herbaria), I failed to find any significant intergrading in leaf-width character with var. *angustifolia*.

In my revisional treatment of *Dubautia*, I had included var. *strigosa* Skottsb., citing the islands of Oahu, Maui, and Hawaii for the geographic distribution. St. John (p. 30) separates the Oahu material as a new variety, *pauoaensis*, and the Maui material as a new variety, *glandulosa*. It is not my intention now to express opinion upon the validity of these two newly proposed varieties. It should be stated, however, that Skottsberg (op. cit. 277) had already noticed the Maui plants, but construed them as merely a form of his then new var. *strigosa*. Thus he wrote: "A very similar form (Fig.

7 e–g) was collected by Hillebrand on E. Maui, s. slope of Haleakala. . . . It differs from most specimens seen, of both species and variety, in the smaller number of flowers, only 5 to 6 or sometimes 7, against 7–9 which is the common number.'' Curiously, Skottsberg and St. John both examined and cited Hillebrand's material from East Maui, yet Skottsberg noted only the fewer florets per head and St. John (who made no mention of Skottsberg's earlier observation) omitted this character entirely but stressed mainly the smaller involucral bracts. By way of explaining my own monographic treatment of var. *strigosa* in its broader sense, I may add here a few brief remarks. Skottsberg was at that time (1935) easily the best known authority upon the genus *Dubautia*, having made extensive collections of *Dubautia* in 1922 (some seven years before St. John's residential study of the Hawaiian flora began) and again in 1926, and having published considerable text, illustrated with three series of excellent sketches (op. cit., 276–281, *figs. 7 a–h*, *8 a–i*, and *9 a–g*). I was much impressed with his appraisal of the East Maui plant as "a very similar form," apparently not meriting a distinct status. I naturally attributed to the lone Oahu collection cited by St. John for his new var. *pauoaensis* (*Rock 215*) a comparable value and so retained it, as well as the East Maui plant, under var. *strigosa* Skottsb.

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THE GILIA AGGREGATA GROUP

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Elongated clusters of bright red trumpet-flowers on two-foot stalks clothed below with lacy foliage attract the attention of layman and naturalist alike in many parts of the western United States. Exhaling a mephitic odor, these plants are inacceptable to grazing animals, and may become abundant even in well-pastured areas. They are known locally as "ruby honeysuckle," "scarlet bugler," or "skyrocket"; the Indians,[1] among other names, used "timpiute." A specimen was collected in what is now Idaho by the Lewis and Clark expedition in 1806, and named by Pursh in 1814 "Cantua aggregata," but the current assignment is to a section *Ipomopsis* of the genus *Gilia*. To obviate the need for publishing numerous new combinations, this is followed here, although the generic independence of *Ipomopsis* may some day be accepted.

The "timpiutes" vary markedly from place to place in stature, pubescence, leaf-segment outline, length and extent of union of sepals and petals, shape of sepal- and petal-blades, color of petals—from deepest red to purest white,—and length of stamens. Some taxonomists consider all the variants to constitute a single species with multiple subdivisions, while others separate the complex into several species.[2]

The principal exponent of the multi-species viewpoint was Greene, who in his writings of 1905, 1906, and 1914 recognized no less than twelve. His diagnoses were, however, brief, and did not always correspond closely to the features of the type specimens. In contrast, Brand in 1907 erected a complex "Systema speciei" comprising 2 subspecies, 2 varieties, 2 subvarieties, and 3 forms. He classed many of Greene's entities as equivalents of previously known ones, but as he paid little attention to original descriptions or type specimens his conclusions are not dependable. Since sweeping reduction of epithets to synonymy is likely to obscure interesting relations between morphology and geography, all which have been validly published are accorded a place in the present treatment.

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[1] Indian names and uses of these plants are discussed in: Train, et al., Medicinal uses of plants by Indian tribes of Nevada. Contr. Flora Nevada No. 33, Publ. Div. Pl. Expl. Intr. Bur. Pl. Ind. U. S. Dep. Agr. pt. 2: 76. 1941.

[2] The generalization by Jepson in Flora Calif. 3(2): 174 (1943), that "*Gilia aggregata* is an extremely constant species in vegetative organs and in the character of its flowers" is difficult to reconcile with its segregation by various workers into 15 or more species. It can easily be refuted by close examination of the sheets in the *Gilia aggregata* folders in any herbarium.

Field and herbarium study of the group soon showed that there are several geographic trends, exhibited especially in calyx and corolla characters. In spite of the existence of occasional intermediates, then, the recognition of more than one species seemed desirable. The members with relatively slender corolla-tube and pale corolla-hue proved to be separable into four entities differing in corolla and/or calyx characters; and those with flaring tubes of bright red hue into three more. The epithets applicable to these are: *aggregata* for the most widespread; *arizonica* for a Nev.–N.M. endemic; *attenuata* for a chiefly northern assemblage; *bridgesii* for a Calif. endemic; *candida* for a Colo.–N.M. one; *tenuituba* for a Great Basin assemblage; and *texana* for a dominantly southern assemblage. More or less intergradation admittedly occurs between these, especially where ranges overlap; it seems to be largely the result of hybridization. To attempt to allow for it nomenclatorially would yield aggregations of epithets too complex for practical use.

The nomenclatorial and taxonomic procedures followed in recent papers by the writer are continued here. Subspecies are assigned trinomials without interposed category designation. The only other infra-specific category recognized is that of form; these are referred to primarily by vernacular descriptive terms, although epithets applied to them by previous workers are recorded. Species and infraspecific epithets are decapitalized, no matter what their derivation.

An annotated alphabetical list of the epithets which have been applied to the members of the group under discussion is now given; new combinations are placed in bold-face, earlier ones proving acceptable in italic or small capitals, and rejected ones in ordinary type, enclosed in quotation marks. To save repeating long references, Greene's *Leaflets of Botanical Observation and Criticism* is abbreviated to "Leafl." and Brand's Monograph on *Polemoniaceae* in Engler's *Pflanzenreich* IV 250 to "Pol."

In describing organs showing coalescence of parts the customary pre-evolutionary method of statement, e.g., "calyx cleft to $\frac{1}{3}$ its length," is avoided. Instead, the extent of union of sepals and petals is given, their free parts being then termed the blades.

For duplicate sheets bearing the same number as the holotype the term replicate is used instead of the more familiar "isotype." The latter implies that a collector or distributor has seen to it that multiple sheets with a given number carry specimens of the very same entity, whereas in critical groups like the *Polemoniaceae* this not infrequently fails to be done.[3]

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[3] Earlier botanists, according to Jackson's *Glossary*, used isotype for "forms common to different countries." In 1919 Pennell, in Torreya 19: 13, redefined the term to signify sheets bearing the same number as the holotype. He pointed out that "such a term should emphasize the importance of all duplicates being thoroughly like the type"; but unfortunately there is no way to make this retroactive, nor to enforce its application.

EPITHETS PROPOSED IN THE GILIA AGGREGATA GROUP

(Comprising Gilias of biennial duration, dissected leaves, thyrsoid inflorescence, and relatively large funnel-salverform corollas of red, yellow, pink, or white hues, the petal-blades acuminate to obtusish.)

AGGREGATA (Pursh) Spreng. "Cantua aggregata" Pursh, Fl. Am. Sept. **1**: 147. 1814; "Ipomeria aggregata" Nutt. Gen. N. Am. Pl. (1): 124. 1818; *Gilia aggregata* Spreng. Syst. Veg. (16) **1**: 626. 1825; "Batanthes aggregata" Raf. Atl. Jour. **1**(4): 145. 1832; "Collomia aggregata" Port. apud Rothr. Rep. U. S. Geogr. Surv. w. 100° **6**: 198. 1878; "Callisteris aggregata" Greene, Leafl. **1**: 159. 1905; same, reinterpreted, ibid.: 224. 1906. The type specimen, *Lewis*, June 26, 1806, in the American Philosophical Society herbarium deposited at the Academy of Natural Sciences of Philadelphia, is a wretched scrap. Its herbage is pubescent with both copious minutely glandular and sparse long eglandular hairs. The sepals are 6 mm. long, and united ⅖ their length to a subcampanulate tube, the blade broad-subulate and short-aristate. The petals are red, and before drying were apparently about 20 mm. long and united ⅔ their length to a moderately thick and flaring tube, the blade being lanceolate and acuminate. Stamens and styles are included, although Pursh's characterization of the style as "brevissimo" represents a misobservation. Through inadvertence the locality was published as "On the banks of the Mississippi"; no doubt "Missouri" was intended, but even that would have been in error; for the label reads "Hungry Creek." This was a point on the Lolo Trail at latitude 46°30′ longitude 115°10′ in what is now Idaho, across the divide from the tributaries of the Missouri.

ARIZONICA (Greene) Rydb. "Callisteris arizonica" Greene, Leafl. **1**: 160. 1905; "Batanthes arizonica" ibid.: 224. 1906; "Gilia aggregata euaggregata subvar. arizonica" Brand, Pol.: 115. 1907; *Gilia arizonica* Rydb. Bull. Torrey Club **40**: 472. 1913; "G. aggregata var. arizonica" Fosb. Am. Midl. Nat. **27**: 764. 1942. The type is from Flagstaff, Ariz. (35–12, 111–39), *Macdougal 148*, May 26, 1891, in U. S. Nat. Herb. Several other entities were distributed from that locality by him. The entity represented by the type is characterized by short broad sepal-blades, short corollas, and deeply included stamens.

ATTENUATA (Gray) Nels. "Gilia aggregata var. attenuata" Gray, Syn. Fl. N. A. (2)**1**: 145. 1878; *Gilia attenuata* Nels. Bull. Torrey Club **25**: 278. 1898; "Callisteris attenuata" Greene, Leafl. **1**: 160. 1905; "Batanthes attenuata" ibid.: 224. 1906; "G. aggregata euaggregata var. attenuata" Brand, Pol.: 115–116. 1907. The type is a specimen collected by Parry in 1864 in Middle Park, Colo. (ca. 40–15, 106–15), in Gray Herb.; others of his collections there are different entities. The typical representative has the sepals about half united and a pale corolla with a short, slender tube and lanceolate-attenuate blades.

(aurea.) "Gilia aggregata f. aurea" Macbr. & Pays. Contr. Gray Herb. **49**: 64. 1917. Type from Martin, Idaho (43–31, 113–34), *Macbride & Payson 3082*, July 7, 1916 in Gray Herb. This represents a yellow color-form which is occasional in southern Idaho and rare elsewhere. Having exserted stamens, it is to be assigned to: *Gilia aggregata formosissima* f. **aurea** (Macbr. & Pays.) Wherry, comb. nov.

"australis." This epithet, placed on labels by Heller, was merely cited as a synonym of his "Gilia aggregata euaggregata subvar. arizonica" by Brand, Pol.: 115. 1907, so is not validly published. As type was designated a sheet of *Macdougal 52*, June 4, 1888, from Flagstaff, Arizona (35–12, 111–39), in Delessert Herb. Replicates in American herbaria bear specimens of *G. arizonica*, of *G. texana*, of *G. aggregata*, or of intermediates (hybrids?) between these. The epithet need not be validated.

Gilia bridgesii (Gray) Wherry, comb. nov. "G. aggregata var. bridgesii" Gray, Proc. Am. Acad. **8**: 276. 1870; "Callisteris bridgesii" Greene, Leafl. **1**: 160. 1905; "Batanthes bridgesii" ibid.: 224. 1906; "G. aggregata bridgesii" Brand, Pol.: 115–116, 1907. Type from eastern Mariposa county, Calif. (ca. 37–45, 119–35), *Bridges 174*, in Gray Herb. In the original description, Gray characterized the sepal-blades as "lato-subulatis immo deltoideis"; in the Syn. Fl. **2**(1): 145 (1878) he expanded this to "shorter and broader, from subulate-lanceolate to deltoid." Brand rendered it simply as "breviter triangulares." The type of sepal-blade to which they were referring is characteristic of species other than *G. aggregata*. However, the present entity differs from all other members of the group in lax habit, obtusish leaf-segments, narrowly deltoid barely awned sepal-blades, and pink corolla with the petals united ⅗ to ¾ their length to a moderately slender tube. As it is, moreover, endemic in a restricted area in east-central California, Greene's view that it deserves species status is believed to be justified. Its closest relative appears to be *Gilia texana*, which approaches its range on the northeast.

CANDIDA Rydb. Bull. Torrey Club **28**: 29. 1901; "Gilia aggregata euaggregata var. attenuata f. candida" Brand, Pol.: 115–116. 1907; "G. attenuata synonym" Coult. & Nels. Man. Rocky Mts.: 400. 1909. Type from La Veta, Colo. (37–30½, 105–00½), *Vreeland 602*, 1900, whereabouts unknown. Cotypes are characterized by having the sepals united ⅗–¾ their length, the blades being at first rounded, then abruptly contracted to a broad-subulate aristate tip; and the white to pink corolla long, slender-tubed, with elliptic (or according to Rydberg obovate) and obtusish petal-blades. These characters are regarded as sufficient to separate this entity from its nearest relative, *Gilia attenuata*. It falls into two subspecies; the original one may be known as: *Gilia candida* **vera** Wherry, nomen novum pro plantam originariam.

(collina.) "Callisteris collina" Greene, Leafl. **1**: 159. 1905; "Batanthes collina" ibid.: 224. 1906; "Gilia aggregata synonym" Brand, Pol.: 115. 1907; "G. attenuata synonym" Coult. & Nels. Man. Rocky Mts.: 400. 1909; "G. attenuata collina" Ckl. ex Dan. Univ. Mo. Stud. Sci. **2**(2): 197. 1911. Type from Clear Creek, Denver, Colo. (39–49, 105–00), *Greene*, July, 1870, in Greene herbarium. This is not closely related to either of the species of which it has been made a synonym, but intergrades with a third, so is here classed as *Gilia candida* **collina** (Greene) Wherry, stat. nov. It may represent a hybrid with *G. texana*. See "G. greeneana," below.

(elegans.) A figure published by Lindley, Bot. Reg. **15**: *pl. 1281* (1829), under the name "Ipomopsis elegans," represents not the eastern plant so named by Michaux, but the western *Gilia aggregata formosissima.*

(euaggregata.) *Gilia aggregata euaggregata* Brand, Pol.: 115. 1907. In assigning the third epithet to the subspecies including the type, Brand gave no description. It is here accepted for material with the corolla-tube 20 to 30 mm. long and the stamens included.

(flavida.) "Callisteris flavida" Greene, Leafl. **1**: 160. 1905; "Batanthes flavida" ibid.: 224. 1906; "Gilia aggregata synonym" Brand, Pol.: 115. 1907. Type from Arboles, Colo. (37–01, 107–23½), *Baker 532* in U. S. Nat. Herb.; this is a specimen of *Gilia texana* with red corollas which faded more or less to yellow in press. It may be known as *Gilia texana* f. **flavida** (Greene) Wherry, stat. nov.

(formosissima.) "Callisteris formosissima" Greene, Leafl. **1**: 160. 1905; "Batanthes formosissima" ibid.: 224. 1906; "Gilia aggregata synonym" Brand, Pol.: 115. 1907; "G. formosissima" Woot. & Standl. Contr. U. S. Nat. Herb. **16**: 161. 1913. Type from southern Black Range, N. M. (32–55, 107–45) *Metcalfe 1318*, 1904, in U. S. Nat. Herb. As this differs from the original representative in having conspicuously exserted stamens, it is here made: *Gilia aggregata* **formosissima** (Greene) Wherry, stat. nov. Only subspecies status is admitted because there is complete intergradation in respect to stamen-length, and but little geographic segregation: exserted-stamen plants are more frequent westward, but may appear throughout the species range.

"greeneana" Woot. & Standl. Contr. U. S. Nat. Herb. **16**: 161. 1913. This was put forward as a substitute for "Callisteris collina" Greene and would be accepted were the entity concerned taken up as a species of *Gilia* (there being a prior *G. collina,* belonging to another group). Only subspecies status is here recognized, however, and in that the epithet *collina* is available.

(helleri.) "Gilia aggregata euaggregata subvar. helleri" Brand, Pol. 115. 1907. Type from Lake Waha, Idaho (46–12, 116–50) *Heller 3253,* in Boissier Herb. Replicates in American herbaria consist of variants of *G. attenuata,* with the stamens barely included to barely exserted. The entity deserves only the status: *Gilia attenuata* f. **helleri** (Brand) Wherry, stat. et comb. nov.

(leucantha.) "Callisteris leucantha" Greene, Leafl. **1**: 160. 1905; "Batanthes leucantha" ibid.: 224. 1906; "Gilia aggregata euaggregata var. attenuata f. candida synonym" Brand, Pol.: 116. 1907; "G. attenuata synonym" Coult. & Nels. Man Rocky Mts.: 400. 1909. Type from Upper Bear Creek, Colo. (39–36½, 105–29) *Greene,* July 26, 1889, in Greene herbarium. This is a minor variant of the species with long well-united sepals, distinguished only by its "oblong-acutish" petal-blade, so may become: *Gilia candida vera.* f. **leucantha** (Greene) Wherry, stat. nov.

(macrosiphon.) "Gilia aggregata var. macrosiphon" Kearn. & Peeb. Jour. Wash. Acad. **29**: 488. 1939. Type from Santa Catalina Mts., Ariz. (32–25, 110–45), *Peebles et al. 2522*, July 22, 1926, in U. S. Nat. Herb. This is related not to *G. aggregata* but to *G. tenuituba;* differing from the original representative of that only in the somewhat longer corolla, it should be classed as *Gilia tenuituba* f. **macrosiphon** (Kearn. & Peeb.) Wherry, stat. et comb. nov.

(maculata.) "Gilia aggregata var. maculata" Jones, Contr. W. Bot. **12**: 55. 1908. Type from Soldier Canyon, Chihuahua (30–15, 108–15), *Jones,* Sept. 16, 1903, in Pomona College herbarium. Being a minor color-variant, this may become: *Gilia aggregata formosissima* f. **maculata** (Jones) Wherry, stat. nov.

"pulchella" Dougl. ex Hook. Fl. Bor. Am. **2**: 74. 1838; "Callisteris pulchella" Greene, Leafl. **1**: 160. 1905; "Batanthes pulchella" ibid.: 224. 1906; "Gilia aggregata synonym" Brand, Pol.: 114. 1907. Type from lower Spokane River, Wash. (47–53, 118–20), *Douglas*, 1825, in Kew Herb. The sole differentiating feature given in the original description is arachnoid pubescence. Although the writer once, in Graham, Ann. Carn. Mus. **26**: 303 (1937), accepted this as a species distinction, further study has indicated it to be of sporadic occurrence among glabrate material. It is accordingly here reinterpreted as *Gilia aggregata euaggregata* f. **pulchella** (Dougl. ex. Hook.) Wherry, stat. nov.

"scariosa" Rydb. Bull. Torrey Club **31**: 632. 1904; "Gilia aggregata synonym" Brand, Pol.: 115. 1907. Type from Veta Pass, Colo. (37–36, 105–12), *Shear 3590*, July 15, 1896, in Britton Herb. This differs from *G. candida* (the type of which came from the same vicinity) only in the petal-blades being lanceolate; the intersepaline membranes of all members of the group become more or less scarious in age. It may therefore become *Gilia candida vera* f. **scariosa** (Rydb.) Wherry, stat. nov.

(scopulorum.) "Batanthes scopulorum" Greene, Leafl. **1**: 224. 1906; proposed as a substitute for "Callisteris aggregata Greene, probably not Cantua aggregata Pursh." Greene inferred that distinct entities were involved, in that Pursh's type "came from the Pacific slope," whereas Greene was referring to a plant "from the Rocky Mountain region eastward." The geographic separation is much too slight to make species identity improbable, so Greene's proposal is rejected.

TENUITUBA Rydb. Bull. Torrey Club **40**: 472. 1913. Type from Beaver, Utah (38–17, 112–39), *E. Palmer 329*, 1877, in Britton Herb. While closely related to *G. attenuata*, this has the longest corolla in the group, so deserves species status.

TEXANA (Greene) Woot. & Standl. "Callisteris texana" Greene, Leafl. **1**: 160. 1905; "Batanthes texana" ibid.: 224. 1906; "Gilia aggregata euaggregata subvar. arizonica equivalent" Brand, Pol.: 115. 1907; *G. texana* Woot. & Standl. Contr. U. S. Nat. Herb. **16**: 161. 1913; "G. aggregata var. texana" Johnston, Jour. Arnold Arb. **24**: 95, 1943. Type from Guadelupe Mts., Tex. (31–55, 104–50) *Havard*, Sept., 1881, in U. S. Nat. Herb. This entity has been poorly described. Greene termed it "low," but the type specimen is a broken portion of a tall plant; he characterized the calyx as "herbaceous," but in mature flowers it is subscarious; and he classed the corolla as "smallish," whereas it is actually 35 mm. long. Wooton & Standley, Contr. U. S. Nat. Herb. **19**: 525 (1915), keyed it out as having the "lobes of the calyx equaling the tube," although in the type specimen they are shorter. The corolla is bright red and flaring, with the stamens conspicuously exserted as in *G. aggregata formosissima;* but because of the different calyx,—sepals only 5.5 mm. long, united over half their length, the blades deltoid with subulate tip—it is here considered specifically distinct.

(typica.) The epithet "typica" was used by Brand, Pol.: 115. 1907, in varietal status under *Gilia aggregata euaggregata,* although the data he gave were not in accord with the type specimen. This epithet was placed on the labels accompanying specimen No. 745 of the Plantae Exsiccatae Grayanae, but the material was not like the Pursh type, representing instead *G. arizonica.*

(utahensis.) "Gilia aggregata euaggregata var. attenuata f. utahensis" Brand, Pol.: 115–116. 1907. Type from Alta, Utah (40–35½, 111–38), *Jones 1122,* July 31, 1879, presumably destroyed in the Berlin-Dahlem herbarium. In such case, the replicate in the Gray Herb. may be taken as neotype. As this differs from other long-tubed material only in slightly longer sepals, it may become *Gilia tenuituba* f. **utahensis** (Brand) Wherry, comb. nov.

(ventrensis.) "Gilia aggregata euaggregata var. attenuata f. ventrensis" Brand, Pol.: 115–116. 1907. The type specimen of this, *Howard 186* from the Gros Ventre valley, Wyoming (ca. 43–30, 110–13), was mistakenly stated to be in the Gray Herbarium, and neither it nor any replicate has been seen. The description indicates it to be a minor variant, with subexserted stamens, so it may become: *Gilia attenuata* f. **ventrensis** (Brand) Wherry, comb. nov.

(vera.) Subspecies *vera* was applied above to the original *Gilia candida.*

(violacea.) "Callisteris violacea" Greene, Rep. Spec. Nov. **13**: 324. 1914; "Gilia aggregata equivalent" Dayton, Bull. Torrey Club **55**: 71. 1928. Type from Montezuma Nat. For., Colo. (ca. 37–30, 108–10), *U. S. For. Serv. 11544,* in U. S. Nat. Herb. Having a long narrow corolla-tube, this color-form may be known as: *Gilia tenuituba* f. **violacea** (Greene) Wherry, stat. nov.

KEY TO THE GILIA AGGREGATA GROUP

(based on measurements of flowers in mid-anthesis)

LEAF-SEGMENTS obtusish; habit lax; sepals united ½–⅗ their length of 5–7 mm., the blade narrow-deltoid, barely awned; corolla pink, 30–45 mm. long; petal-blade oblong; stamens included or barely exserted. Endemic in east-centr. Calif., lat. 36°15′ to 39°. 1. *G. bridgesii.*

LEAF-SEGMENTS acutish; habit strict (or lax in mutants).

CALYX cylindric, the sepals united ⅗–¾ their length of (6) 8–10 mm., the blade obtuse, abruptly contracted to a subulate-aristate tip; petals united ¾–⅘ their length of (25) 30–45 mm. Endemic in Colo. and adj. N. M., long. 108° to 112°. 2. *G. candida;* ssp.:

COROLLA-HUE white to pink; tube little expanded upward; blade obtusish to acutish and oblong (f. *leucantha*) to lanceolate (f. *scariosa*). a. *vera.*

COROLLA-HUE deep pink to red; tube more or less expanded upward; blade lanceolate. Apparently mostly of hybrid origin. b. *collina.*

CALYX subcampanulate; sepal-union not over ⅗ the length.

COROLLA-TUBE slender with but slight upward expansion; hue pale or rarely deep; sepal-blades broad- to narrow-subulate.

COROLLA-LENGTH 25–30 (35) mm.; hue white, yellow, or pink; stamens included to subexserted (f. *helleri*, f. *ventrensis*); sepals united ⅓–½ their length of 5.5–9 mm., usually rather long-awned. Range from ne. Wash. to centr. Colo. 3. *G. attenuata.*

COROLLA-LENGTH (30) 35–60 mm. (f. *macrosiphon*); hue white to pink, sometimes purple-streaked or becoming violet on drying (f. *violacea*); sepals united ⅖–⅗ their length of 5.5–9 mm. (f. *utahensis*), usually rather short-awned. Range from e. Calif. to w. Colo. 4. *G. tenuituba.*

COROLLA-TUBE stout, with marked upward expansion, 20–45 mm. long; hue deep red more or less mottled with yellow; pink or yellow in mutants.

SEPAL-UNION ½–⅗ the total length of 4 to 6 (8) mm., the blade deltoid to oblong, more or less abruptly contracted to a subulate tip 0.5–3.5 mm. long, barely to moderately awned.

PLANT tall, (30) 40 to 100 cm. high, often sparse-pubescent; corolla red or drying yellow (f. *flavida*); (27) 30–40 mm. long; stamens more or less exserted. Range n. Calif. to ne. Mex. 5. *G. texana.*

PLANT dwarf, 15–30 (50) cm. high, often dense-pubescent; corolla red, 20–25 (30) mm. long; stamens more or less deeply included. Endemic from s. Nev. to n. N. M. 6. *G. arizonica.*

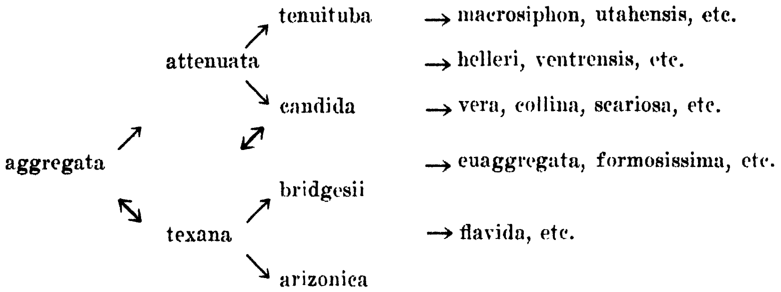
SEPAL-UNION less than half the total length of 6–9 mm., the blade subulate from a more or less broad base, moderately awned. Range, s. B. C. to centr. Mex. 7. *G. aggregata;* ssp.:

STAMENS included; corolla red, yellow-mottled, or rarely yellow; 20–30 (35) mm. long; herbage glabrate to tomentose (f. *pulchella*). More frequent toward east side of range. a. *euaggregata.*

STAMENS exserted; corolla red, yellow-mottled (f. *maculata*) or yellow (f. *aurea*) (25) 30–45 mm. long. More frequent toward west side of range. b. *formosissima.*

EVOLUTIONARY RELATIONS

The key presented on the preceding page is frankly artificial, the sequence of entities being such as to make diagnosis as easy as practicable. The evolutionary relations between the various entities involved can, however, be brought out by a tabulation as in the accompanying chart.


tenuituba → macrosiphon, utahensis, etc.
attenuata → helleri, ventrensis, etc.
candida → vera, collina, scariosa, etc.
aggregata → euaggregata, formosissima, etc.
bridgesii
texana → flavida, etc.
arizonica

Anyone desiring to recognize fewer species than are accepted here will do well to carry out status-reduction in the directions indicated by the arrows.

Relationship of G. aggregata to G. rubra. The closest relative of the entities above discussed is *Gilia rubra* (L.) Heller, otherwise *Ipomopsis rubra* (L.) Wherry. This is a more eastern plant, ranging from Texas to Florida, and its nomenclature has been discussed in the writer's series of studies on eastern *Polemoniaceae*.[4] In proposing the genus epithet "Callisteris" for *G. aggregata* and its allies, Greene[5] stated: "From the *Ipomopsis* of Michaux, itself an excellent genus and monotypic, they differ not only habitally and in foliage, but widely in character of calyx and seeds." It is difficult to account for these assertions. *Gilia rubra*, the *Ipomopsis* of Michaux, is remarkably similar in habit to *G. aggregata*, merely lacking glandular pubescence and having filiform leaf-segments. Measurements of the calyx on some 25 specimens show its length to average 8 mm. and the subulate sepals to be united ⅖–½ their length, essentially as in *G. aggregata*. The seeds of some forms of *G. rubra* are, it is true, unchanged when moistened, yet in other forms unquestionably belonging to the same species the seed-coat becomes nearly as mucilaginous as in *G. aggregata*. It can only be concluded that Greene exaggerated the dissimilarities, and that whatever generic assignment is ultimately settled upon, *G. rubra* and the *G. aggregata* group will be considered congeneric.

DEPARTMENT OF BOTANY, UNIVERSITY OF PENNSYLVANIA
PHILADELPHIA, PENNSYLVANIA

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[4] Bartonia No. 18: 56. 1936.

[5] Leaflets Bot. Obs. & Crit. 1: 159. 1905.

BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 73, No. 2, pp. 203–207 MARCH, 1946

TORREYA

SHORT ARTICLES AND NOTES

Notes on the Grasses, Sedges and Rushes of the Great Swamp (New Jersey).[1] During the spring and summer of 1944 the authors collected all mature grasses which they could find growing in the survey area of the Great Swamp.

The Great Swamp lies in Chatham Township, Morris County, south of the town of Chatham. The survey area is a half mile square. The northern boundary starts at the point where the Public Service high power line crosses Southern Boulevard and follows the latter one-half mile west. The eastern boundary runs south from Southern Boulevard one-half mile along the high power line. The northern portion of the area is on the Wisconsin terminal moraine where the soil is a sandy loam with a pH of 5.17 in the open fields. As one goes south through the area and down into the swamp proper, the soil becomes a black silt which in certain areas is in the early stages of peat formation with a pH as low as 4.19.

All of the specimens were determined by Mr. Bayard Long of the Academy of Natural Sciences of Philadelphia. The specimens are in the Rapp Herbarium, the Chrysler Herbarium at Rutgers University, and the Academy of Natural Sciences of Philadelphia.

GRAMINEAE

The grasses growing in the Great Swamp are cosmopolitan species growing throughout the eastern United States. Many of the grasses might be called prairie species, since they are common in the prairie region of Middle North America.

The sequence of tribes and genera follows that of Hitchcock's "Manual of Grasses of the United States."

Festuceae. Fescue Tribe

POA COMPRESSA L. Canada Bluegrass. Found everywhere except in the dense woodland and in the very wet places. We took mature specimens 28 June 1944.

TRIODIA FLAVA (L.) Smyth. Favors open fields and woods. It is common on the midwestern prairie. Mature specimens were taken 2 September 1944.

Oryzeae. Rice tribe

LEERSIA VIRGINICA Willd. Common in the damp woods and along the paths. Mature specimens were taken 13 August 1944.

Paniceae. Millet Tribe

PANICUM MICROCARPON Muhl. A woodland species prefering acid soil. Mature specimens were taken 28 June 1944.

PANICUM DICHOTOMUM L. Found in the open areas, especially on the moraine where the soil is sandy. Mature specimens were taken 28 June 1944.

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[1] Fourth contribution to the Great Swamp Ecological Survey.

PANICUM LINDHEIMERI var. FASCICULATUM (Torr.) Fernald. Common in moist places near the bottom of slopes. Mature specimens were collected 28 June 1944.

Andropogoneae. Sorgum Tribe

ANDROPOGON SCOPARIUS Michx. Prairie Beardgrass. Common in the open fields in the northern part of the survey area. Mature specimens were collected 2 September 1944.

CYPERACEAE

We collected two genera from the Great Swamp, *Scirpus* and *Carex*. Most of the species are widely enough distributed to occur in the prairie region as well as in the eastern United States.

The arrangement here follows that of Deam's "Flora of Indiana."

SCIRPUS ATROVIRENS Muhl. Common on wet mucky soil. Specimens were collected 28 June 1944.

CAREX ANNECTENS Bickn. Collected in the drier areas of the Swamp particularly where the soil was more acid. Mature specimens collected 28 June 1944.

CAREX SCOPARIA Schkuhr. This species seemed to prefer open wet areas in the swamp. Specimens were collected 28 June 1944.

CAREX STRICTA Lam. Found in wet places both in open regions and under trees. We collected mature specimens 30 July 1944.

JUNCACEAE

JUNCUS EFFUSUS L. Found in low portions of fields and in wet open woods. Mature specimens were taken 28 June 1944.

JUNCUS TENUIS Willd. A coastal plain species which has migrated back into the Piedmont plain. Mature specimens were taken 28 June 1944.

LUZULA ECHINATA (Small) Hermann. Fairly common in the open woods on drier slopes. Mature specimens were collected 28 June 1944.—WILLIAM F. RAPP, JR. AND JANET L. C. RAPP.

Additional Introduced Plants in the Aleutian Islands.[1] Considerable interest attends the introduction of plants into the Aleutian Islands, because conditions there suggest that these islands could support a better flora than they now possess. Until recently few attempts have been made to introduce plants except for some scattered planting of trees in the eastern end of the chain. There are a few of the ubiquitous weeds which have inevitably come along whenever the few white inhabitants have undertaken agriculture. The attempts to introduce trees have been ably summarized in a recent article in the Geographical Review for July, 1945,[2] with some data on weather conditions bearing on their survival possibilities.

It is usually necessary in studying introduced plants to search out-of-the-way places for records of their first appearance, or to derive this information by deduction and assumption. It may be anticipated that sometime in the future knowledge will be needed of the introductions made during the recent military occupation of these islands. It seems advisable, therefore, to record here some introductions additional to those noted in the Geographical Review and to suggest that other records be published where future students can readily obtain them.

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[1] Published by permission of the Secretary of the Smithsonian Institution.

[2] **Bruce, David, & Court, Arnold.** Trees for the Aleutians. Geogr. Rev. 35: 418–423. 1945.

In the collections from Attu Island made in 1944 by Lt. G. B. Van Schaack of the U. S. N. R. and Mr. Robert Morehouse of the U. S. Army, there appeared specimens of *Brassica napus* L., rape, and *B. juncea* (L.) Coss., brown or Indian mustard. These were identified by L. H. Bailey, who has given special attention to the cultivated brassicas and has urged the collecting of more herbarium material of these variable and widespread crops. The Attu collectors reported that the plants appeared to have sprung from seeds dropped from Japanese military stores during their short occupation of this island. There was no indication that they were deliberately planted. The fact that these specimens were in full flower suggests the ability of the species to survive an Aleutian winter. However, Lt. Van Schaak reports that these were not seen during 1945.

Lieutenant Soren Nelson, of the Army Engineers, recently reported to the Smithsonian Institution a list of seeds of trees and shrubs which were sown on Amchitka Island during May, 1945 on bone-heap mounds left by the Aleuts. The species planted are reported to be *Pinus strobus*, *Tsuga canadensis*, *Tsuga caroliniana*, *Picea canadensis*, *Abies balsamea*, *Amelanchier laevis*, *Crataegus submollis*, *Betula papyrifera minor*, *Ilex verticillata*, *Cornus stolonifera*, *Rhododendron maximum*, *R. carolinianum*, *Kalmia latifolia*, *Vaccinium corymbosum*, and *Viburnum dentatum*. The seeds were secured from E. C. Haff of the Champion Paper & Fibre Co., Canton, North Carolina. The location of the mounds where these planting were made are shown on a map which appears on p. 23 of the July 1945 issue of the Scientific Monthly showing archeological sites of prehistoric villages.[3] The planted mounds are numbers 12, 15, and 16 on the map, also one at the base of Constantine Harbor on the north side of the island, another just west of site no. 25 in St. Makarius Bay, and the sixth is a short distance further west on the shore of the same bay.

The planting of acidophiles on bone or shell heaps does not forebode great survival. The exact origin of the seeds has not been stated, although a southeastern United States origin is suggested. The northern limit of range of all but one of these species is far south of the latitude of the Aleutian Islands. *Cornus stolonifera*, however, does occur commonly in Alaska.—EGBERT H. WALKER.

BOOK REVIEW

Plantas Medicinales, Aromáticas o Venenosas de Cuba. By Juan Tomas Roig y Mesa. 872 pp. Illustrated. Havana: Republica de Cuba, Ministerio de Agricultura, Servicio de Publicidad y Divulgación (Publicaciones Técnicas). 1945.

This is not only a noteworthy contribution to the literature of the medicinal uses of Cuban plants but is also of value in understanding the flora of that island. Fully informed in the popular medical history and entirely competent in the botany of

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[3] **Guggenheim, Paul.** An anthropological campaign on Anchitka. Sci. Monthly **61**: 21–32. *illustr. map.* 1945.

Cuba, Dr. Roig in the present work has lived up to his customary excellency, if not surpassed it.

The format of *Plantas Medicinales* is good. Although in the body of the book the plants are arranged in alphabetical sequence according to some one selected common name, the copious cross-references and indices are so complete that no difficulty is encountered in tracing any of the species treated. Besides the all-important index to the scientific names of the species, there are indices to their vernacular appellations in Cuba and other American countries, an arrangement of the plants according to the botanical classification of Engler & Gilg, and an extensive grouping according to their applications. In addition, there is a glossary to certain medical terms, and a bibliography of 94 entries dating from 1767 to 1944 listed in chronological sequence. The order generally adopted in treating the species is as follows: a preferred common name in large bold-face type, the scientific name and its family in italics, synonymy, other vernacular names with the regions where they are current, habitat and distribution, detailed botanical description, part of the plant used, applications with ample quotations from other authors, remarks on allied species, the plant's place in industry either local or general, and bibliography. Often chapters on the active principal or chemical composition and therapeutic properties are submitted. These discussions are set off by the use of diverse fonts.

The local names, botanical treatment, and medicinal uses listed in *Plantas Medicinales* often serve as a valuable supplement to those appearing in Dr. Roig's previous important books, *Diccionario Botanico de Nombres Vulgares Cubanos* and *Flora de Cuba* (*Datos para su Estudio*). The botanical collections of Dr. Roig available in the herbaria of The New York Botanical Garden and other institutions attest to his ability as a discriminating botanist and excellent field man, and his experience and knowledge are clearly reflected in *Plantas Medicinales*. This work will also serve as one of the cardinal sources of information when a modern Flora of Cuba is eventually written; and such a flora is urgently needed, for excepting Britton, Wilson & León's incomplete *Catalogue* there is still none for "The Pearl of the Antilles."

The references to the medicinal uses appearing in *Plantas Medicinales* have been painstakingly extracted from numerous authorities, and in many cases by Dr. Roig personally from local sources not available in print. The data are brought compactly together. But there remains one important task still undone. That is the necessity of subjecting the plants, for which there are numerous popular uses and reported properties, to exacting laboratory tests in fully equipped institutions. This study is very difficult and expensive. It requires the collection, often from difficult situations, of ample material of the correct part of a particular species, transportation over long distances to the laboratory where it must arrive in good condition, and then a seemingly infinite series of tests by chemists and pharmacologists. Then there may be only one success out of approximately a hundred tests. Yet all this is necessary, for otherwise the myriad references to plant uses by savages, lay doctors, and the common people individually or collectively, instead of being a precious heritage from countless generations, are a vain and valueless encumbrance of the literature in which they appear.

The importance of such studies is well understood by Dr. Roig, for in his "Prólogo" he avows that one of his objectives in writing *Plantas Medicinales* is to induce scientists to study the Cuban plants reputed to be medicinal or poisonous; and he has repeatedly called attention in various articles and conferences to the desirability of subjecting these plants to chemical and clinical tests. He has also personally collected samples of some of the plants discussed in his book for analyses when the facilities of some of these tests have been made available to him.

Plantas Medicinales is an important work, presented by a capable man, who is willing to make improvements on his own work.—JOSEPH MONACHINO.

PROCEEDINGS OF THE CLUB

Minutes of the Meeting of October 2, 1945. The regular evening meeting of the Torrey Botanical Club was called to order by President Seaver at the Brooklyn Botanic Garden at 8.15 p.m. with 28 members present.

The Minutes were approved as read.

Two new members were accepted by the Club, one for associate membership, and one for annual membership.

Dr. Matzke moved that the Torrey Botanical Club publish in the Bulletin an account of the life and work of Professor C. C. Curtis who died April 10, 1945. The motion was carried unanimously.

Dr. Graves moved, and Dr. Avery seconded, a motion to approve a special meeting of botanists with the active participation of the Torrey Botanical Club early in January in honor of the New York Botanical Garden's fiftieth anniversary.

The rest of the meeting time was taken up with reports of summer field experiences. Dr. Small reported on the field trips of the Club. Dr. Shull reported on the summer work of the committee working to preserve Island Beach in its natural state. Dr. Lela Barton told of three weeks' visit in Guatemala and at Merck and Compay's Cinchona plantation there.

The meeting was adjourned at 9.20 p.m. and refreshments were served.

Respectfully submitted,

FRANCES E. WYNNE,
Recording Secretary

Minutes of the Meeting of November 7, 1945. The regular evening meeting of the Torrey Botanical Club was called to order by President Seaver at Hunter College at 8.15 p.m. with 40 members and friends present.

The minutes were approved as read.

Two persons were unanimously elected to annual membership.

There was no business, so the remainder of the meeting time consisted of a scientific program by Dr. Bassett Maguire: "Plant Collecting in the Desert and Mountain Regions of Nevada." The speaker's abstract follows:

> The New York Botanical Garden–Utah State Agricultural College Intermountain Region field study for 1945 was made in south-central Nevada and adjacent California. For more than three and one-half months, intensive collecting was carried on in the Quinn Canyon, the Monitor, Toquima, Toiyabe, and Shoshone Ranges, and intervening low desert areas in Nye County, the Silver Peak Range, Esmeraldo County, and the White Mountains in Inyo and Mono Counties, California.

Report on the itinerary, the terrain and vegetation was made by means of kodachrome slides.

After the showing of excellent kodachrome pictures, there was considerable discussion.

The meeting was adjourned at 9.45 p.m. and tea was served by the Hunter Faculty.

Respectfully submitted,

FRANCES E. WYNNE,
Recording Secretary

INDEX TO AMERICAN BOTANICAL LITERATURE

PLANT TAXONOMY AND FLORISTICS

(exclusive of fungi)

(See also under Morphology: **Erdtman**; Martens)

Allard, H. A. An interesting raspberry, *Rubus illecebrosus* Focke, new to West Virginia. Castanea **10**: 113–115. D 1945.

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BULLETIN OF THE TORREY BOTANICAL CLUB
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PROPOSED NAMES FOR THE PHYLA OF ALGAE

GEORGE F. PAPENFUSS

Although the term Thallophyta[1] is still useful as the inclusive name for a number of groups of plants of a certain morphological level, it has long been recognized that this name has become obsolete as a phyletic designation.

The algal component of the Thallophyta has been variously subdivided by different writers into a number of phyla. The system which for a long time was followed was that of Engler in the third and subsequent editions of Engler and Gilg's *Syllabus der Pflanzenfamilien*. Finally, Engler arranged the algae under nine phyla as follows: Schizophyta, Flagellatae, Dinoflagellatae (including possibly his Silicoflagellatae), Bacillariophyta, Conjugatae, Chlorophyceae, Charophyta, Phaeophyceae, and Rhodophyceae.

With the advance of knowledge it has become increasingly clear that this arrangement is also to be abandoned. At present there are two systems: That of Pascher (1931[2] and earlier papers), which has become well-known through its adoption, with slight modification, by Smith[3]; and that of Fritsch as outlined in the first volume of his work, *The structure and reproduction of the Algae* (1935, pp. 4–11).

Pascher divides the algae into the following eight phyla: Chrysophyta, Phaeophyta, Pyrrhophyta, Euglenophyta, Chlorophyta, Charophyta, Rhodophyta, and Cyanophyta. Fritsch on the other hand does not assign the algae to phyla, but arranges them under eleven classes as follows: Chlorophyceae, Xanthophyceae, Chrysophyceae, Bacillariophyceae, Cryptophyceae, Dinophyceae, Chloromonadineae, Euglenineae, Phaeophyceae, Rhodophyceae, and Myxophyceae. Both Fritsch and Smith look upon *Chara* and its allies as forming a category of the true green algae.

Inasmuch as class is a category below the level of phylum and since there, at present, is no justification for looking upon all algae as composing a single phylum, the system of Fritsch does not constitute a complete and well-rounded arrangement.

The system of Pascher thus remains as the one which is most acceptable. The phyletic names used by him were recently criticized, however, by Papenfuss[4] on the ground that they do not contain the old and well-established

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[1] First proposed by Unger in 1838, according to Just (Bot. Rev. 11: 302. 1945), but brought into prominence by Endlicher in his *Genera Plantarum* (1836–1840).

[2] Beih. Bot. Centralbl. 48: 317. 1931. Some of the names used by Pascher were first proposed by Wettstein (*Handbuch der systematischen Botanik*, 1901).

[3] Cryptogamic Botany, Vol. 1. 1938.

[4] Madroño 7: 226. 1944.

[THE BULLETIN for March–April (73: 103–216) was issued March 15, 1946.]

connotation "phykos." Another objection lies in the designation *Chlorophyta* as the exclusive name for a group of algae.

Since names are a convenient means of referring to things, it is desirable that they be distinctive. The appellations of Pascher fulfill this requirement to a large extent in that they terminate in "phyta" and therein conform to the phyletic designations of other plant groups.

If the names of algal phyla contained the connotation "phykos" also, they would have the added merit of being explicit as to the kinds of plants to which they apply. It is with this objective in mind that the following modifications of the designations of Pasher are proposed: Chrysophycophyta, Phaeophycophyta, Pyrrhophycophyta, Euglenophycophyta, Chlorophycophyta, Charophycophyta,[5] Rhodophycophyta.[6]

In making these names the Greek word φῦκος, meaning seaweed, is taken as synonymous with alga, as has been the custom for a long time. It is true that at first glance the names seem ponderous but with the accepted practice of accenting the antepenult the pronunciation is both easy and euphonious, for example, Chloro · phy · co phy · ta.

It may be argued that these designations are outlawed by the rule of priority. The same objection could, however, be raised also with respect to certain of the names of Pascher or of some of those currently used for certain other plant phyla. If the rule of priority were strictly adhered to, the name Thallophyta would have to be retained for one of the phyla of lower plants. For the same reason the designation Stelophyta (cf. Just, op. cit.) would be invalid as a name for vascular plants; or the name Bacillariophyta may have to be retained for Pascher's Chrysophyta, which phylum, however, includes, in addition to the diatoms (Bacillariophyceae), two classes of organisms which in no way could pass as diatoms.

It is clear that the retention of outmoded phyletic names would not be in keeping with present-day knowledge of plant relationships and, as has been pointed out by Just (op. cit.), it becomes desirable that the question of the names of higher categories be reviewed at the next International Botanical Congress. Furthermore, it seems desirable that legislation which may be passed relative to these designations be flexible enough to permit revision of the names in the light of further knowledge concerning plant phylesis.

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[5] In agreement with Pascher and others this group of algae is considered sufficiently distinct from the true green algae to deserve the rank of phylum.

[6] The blue-green algae or Cyanophyceae are taken as constituting a class in the phylum Schizophyta.

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A CURIOUS FUNGUS ON OPUNTIA

B. O. DODGE

While studying fungous diseases of cacti from Florida some years ago, I very frequently came across the tiny "fruiting bodies" of a fungus which was quite unlike any species known to me. Thaxter, Peck, or von Hoehnel, with their great knowledge of bizarre forms of fungi, might have recognized this fungus if it had been brought to their attention and so would have been able to point out just where it had been described long ago. For me it was not possible to place it even in a Class either among minute species of the higher forms or among the Fungi Imperfecti. The fungus was clearly not very destructive to its host, *Opuntia ammophila*. Since I hoped to find eventually where it had been described and to learn something more about its morphology and life history, it was not mentioned in the short articles on *Opuntia* diseases which I published at that time (1937–1939). Miss Bass Guttman, at my request, made a few sketches from slide mounts which I had hastily prepared for the purpose. Some of these sketches, together with photographs taken recently for me by Mr. E. N. Mitchell of our staff, are reproduced in figures 1 and 2 herein.

The little fruiting bodies, as they may be called for convenience, consist of two parts, a stalk and a cap. The stalk is dark brown, about 200–500 μ in length, tapering from about 40 μ in diameter at the base to about 20 μ at the top. It is curiously made up of segments or joints simulating in miniature the fertile stalks of the common horsetail, *Equisetum arvense*. In both plants the joints can be easily separated. The drawings and photographs (figs. 1, 2) show that the rind, or outer layer, of the top segments of the stalks either can be slipped off from the core, which is solid, or it develops after the cap is dislodged. The hyphae which compose the outer wall as well as those of the core seem to grow more or less parallel up the stalk. Since the hyphae of the rind at least of one segment do not continue straight into the next segment, it may be (although I have no direct evidence for this) that each segment, as it forms, develops its own cap, which as it matures is pushed off or thrown off. After this occurs the stalk cells may proliferate or regenerate and so grow up to make another segment, which in turn would develop a cap, throw it off, and send up a third joint, and so on. The photographs show at least ten joints in some of the stalks.

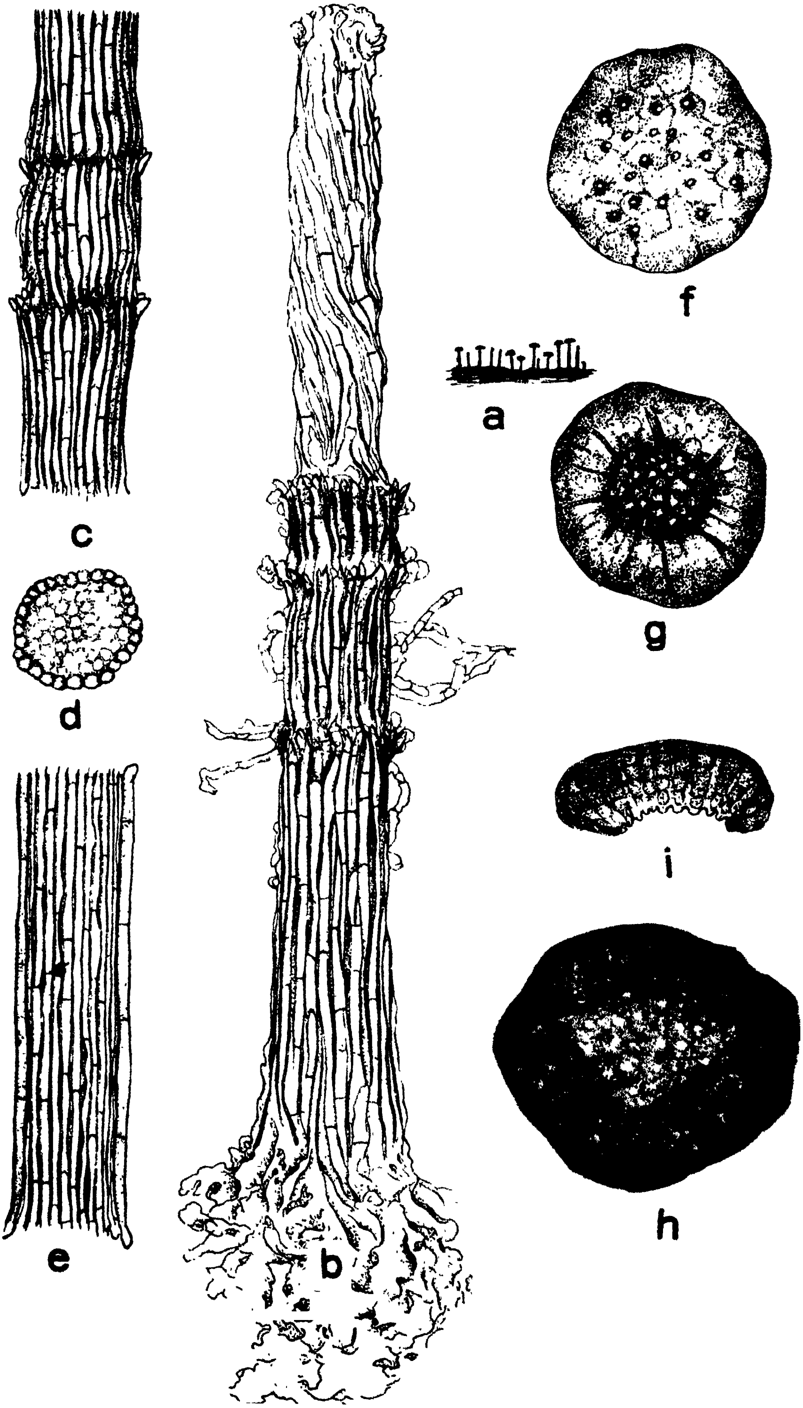
One reason why one finds so many little caps lying directly in contact with the surface of the cactus pad, entirely apart and at some distance from the stalks on which they originally grew, is the ease with which these caps can be dislodged and so go sailing off to land elsewhere. We found on the cactus pads, as they arrived from Florida, many stalks which had lost their caps. It may be that through the cooperation of the thrust of the upward-growing stalk-hyphae and the highly elastic shell of the attached cap, the latter would be thrown off with some force when the connection between cap and stalk is broken. Anyway, this would be good material for observation and experimentation on the discharge of propagating bodies.

The caps are dark brown, almost black. They measure 50–80 μ in diameter; they are about 20–25 μ in thickness, somewhat concavo-convex in shape, the edge thick, something like a minute doughnut, except that the hole extends only partly through. This depression represents the place of attachment of the cap to its stalk. Those who are familiar with *Boleti* and have pulled a stalk from its pileus will have no trouble in visualizing the shape and parts of our little fungus.

While mounts of caps show that the outer layer or covering is hard, dark brown, and brittle, it seems to be perforated here and there, giving a sort of pepper-box effect. Whether these bright spots are holes or only thin places in the chitinous outer layer is uncertain (fig. 1*f*). Crude cross sections of caps (fig. 1*i*) show rows of cells, about four cells to the row, extending out from the border of the depression on the under side. Possibly these radiating rows originate from the core cells of the stalk. Whether the common number four in each of the rows has any significance is doubtful.

Pure cultures of this fungus are very easily obtained if one simply removes a cap directly from its stalk with a wet needle and places it on the surface of an agar medium in a plate. Within two or three days branched septate hyphae grow out from the cap. From which cells of the cap these germ tubes actually arise was not determined. Transfers can be made to tube cultures by cutting off the ends of these hyphae or by transferring the whole cap with its outgrowths, if there appear to be no contaminants present. After three or four weeks one finds that the fungus has developed real stalks which grow up from small mounds or knots of mycelium. These stalks may appear singly or in groups of five or six. In only a few cases did typical caps develop sufficiently to prove absolutely that we had pure cultures of the fungus taken

FIG. 1. *a,* Habit sketch to show *Tretopileus Opuntiae* as it grows on the edge of a cactus pad, seen with a binocular dissecting microscope. The caps of some stalks have been dislodged. *b,* A stalk with four segments; the outer layer or shell of the top segment either had been slipped off or had not formed as yet. *c,* Surface view of one short segment with details seen by the artist. *d, e,* Cross and longitudinal sections showing the core and rind of a segment. *f,* Cap seen from above and showing the pinhole-like spots. *g,* A similar cap viewed from the under side, showing the depression where it had been detached from its stalk. *h,* Another view from below showing the pinholes in the upper surface of the cap as the microscope was adjusted to bring this surface into focus. *i,* Crude section of a cap showing the rows of cells extending outward from the region of attachment of cap to stalk. *b–h,* × 550.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from the cactus. The stalks that developed in these cultures were not segmented or jointed. This may indicate that stalks made up of segments develop only with the successive formation of caps, one after the other, as suggested previously.

It may be that in nature, under certain conditions minute spores are finally developed inside the cap, after which they are sifted out through the pores. On the other hand, these pores or thin places in the outer wall may be a provision for the emergence of germ tubes which would otherwise be unable to penetrate the chitinous outer membrane of the cap. So far as I have discovered, the cap serves, just as we find it, very well as an organ of propagation. It is readily blown off or discharged from its stalk, perhaps with some force, so that it is carried away to a new feeding ground where it germinates.

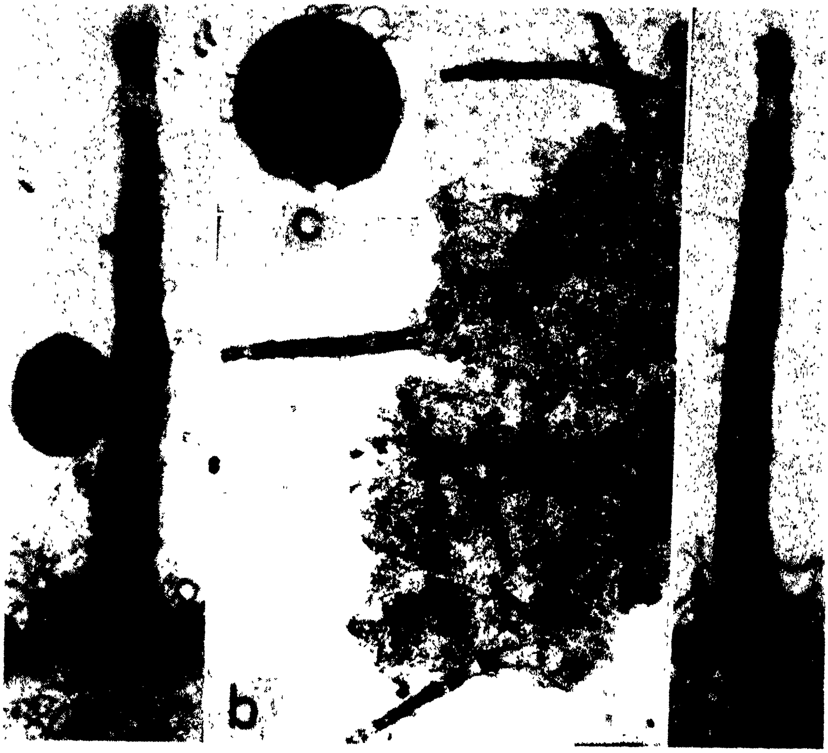

Fig. 2. *a*, Photograph of a stalk having nine segments; the dislodged cap viewed from the under side is at the left below. × 200. *b*, Fragment of the cactus pad bearing eight stalks of the fungus. The caps, if originally present, were dislodged when the mount was made. × 75. *c*, A rather small cap viewed from the under side showing faintly the radiating rows of cells seen through the chitinous outer cover of the cap. × 350. *d*, The stalk at the left center in *b* is shown here more enlarged. It has ten segments. × 200.

Many fungi produce bulbils or minute sclerotia which serve in place of spores. Liverworts develop gemmae, and the editor reminds me that some lichens produce soredia. Perhaps our fungus, in the stage in which we find it, is the sterile form of some lichen like *Calicium*. The coarse brown cells at the joints of the segments of the stalk of our fungus sometimes grow out freely a short distance into the air. I have frequently found a few spores, usually brown and two-celled, associated with similar coarse hyphae around the base of the stalk. Furthermore, one sometimes finds cactus pads bearing short bristle-like coarse brown hyphae arising either singly or in groups of three or four from the pads. One at first easily mistakes these bristles for stalks of our fungus. Microscopic examination, however, proves that these bristles are composed of single hyphal threads made up of rows of thick-walled cells. We have in the Gasteromycetes the genus *Myriostoma* and a *Calvatia* with a well-defined stalk. These similarities are, of course, merely analogies or accidental parallelisms.

I am indebted to Dr. David H. Linder for suggestions on the group to which this fungus might be assigned. He was unable to place it, however, without further information on its life history. In order that reference may be made to this fungus, it is named and described below. The name (suggested by Dr. H. W. Rickett) refers to the pores or thin places in the shell of the cap.

Tretopileus Opuntiae Dodge, gen. & sp. nov. Fructibus per areolas discolores segmentarum cactorum dispertis, e mycelio plus minusve subcuticulari exorientibus; stipite articuloso segmentis 1-10 aliquando separabili, 200–500 μ longo, 20–40 μ crasso, cortice e crasso-tunicatis brunneis hyphis septatis secundum longitudinem stipitis dispositis confecto, medulla e tenuitunicatis cellulis similiter dispositis contecta; pileo 60–80 μ diametro, 20–30 μ crasso, concavo-convexo, membrana superficiali obscure brunnea, dura, chitinea, pluribus poris vel areolis subtilibus munita, cellulis interioribus seriatim radiatimque dispositis, facile ab stipite disjungendo.

On pads of *Opuntia ammophila* and related species, Fort Pierce, Florida, 1937–1939.

Since it is not convenient to continue a study of this fungus, the above notes are put on record in the hope that some mycologist may become interested and complete the story, if it has not already found its place in mycological literature.

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FURTHER CONSIDERATION OF GLANDULAR LEAF HAIRS OF TOBACCO AND OF THEIR SIGNIFICANCE[1]

FREDERICK A. WOLF

From previous studies involving hairiness of oriental varieties of tobacco (Wolf & Jones 1944, Bentley & Wolf 1945), it was concluded that aroma seems to be traceable primarily to the exudate from glandular hairs, that different varieties, when grown under similar conditions, differ in hairiness, and that both hereditary and environmental factors are interdependent in controlling the population of leaf hairs. Apparently the range of variability is governed by hereditary factors, and environment determines the position of the variant within this range. Moreover it was concluded that a measure for evaluating *potential* amount or quantity of aroma of a given leaf before curing is provided by the two correlated criteria: (a) number of hairs per unit of leaf surface, and (b) total number of hairs per leaf. These two criteria may be readily determined from direct microscopic examination of green leaves. Unfortunately means are not yet at hand for determining the accuracy of such evaluation by checking it against *actual* quantity of aroma possessed by leaves after they have been cured and aged. It should be emphasized that methods for measuring directly the quantity of aromatic material or the amount and kind of specific odorous constituents are quite unknown, except by appraisal through the sense of smell. To devise some operable means does not seem to present insuperable difficulties, since it should be possible to remove the volatile constituents from cured leaves by distillation or extraction with solvents and then to isolate them and make quantitative measurements.

Since the amount and kind of aroma are of major importance in appraising quality of oriental tobaccos, further consideration was given to means of modifying the population of glandular hairs. The results of experiments obtained during the past two seasons with selection and hybridization, as well as with experiments concerning variations in the spacing of plants and variation in light are believed further to contribute to an understanding of the problem of aroma, and accordingly are presented at this time.

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[1] These investigations were financed, in part, by the General Education Board. Grateful acknowledgment is made for assistance rendered in the conduct of these investigations by Nancy J. Bentley and Vera Rudin, Graduate Assistants at Duke University. Thanks are also extended to Dr. Paul M. Gross for critical reading of the manuscript, although the author is solely responsible for the interpretations and conclusions herein.

MATERIALS AND METHODS

In general, the procedures employed were identical with those described in a previous report (Bentley & Wolf 1945). The analyses involved plants grown in fields at the Tobacco Experiment Station, Oxford, N. C., as well as supplementary analyses of plants grown under glass at Durham, N. C. Plants found to have leaves more hairy than others of the same variety were selected as seed stock. For comparison non-selected plants, taken completely at random, were used as a seed source.

Plants similarly selected from the F_2 generation constituted the parents used to determine hairiness of crosses between varieties. Their progeny was compared with that of non-selected F_2 parents.

In tests concerning the influence of spacing, the intervals "between rows" and "within rows" were arbitrarily chosen. These spacings were (1) like those commonly employed with flue-cured tobacco, (2) like those commonly used with oriental tobacco, and (3) with twice as many plants per unit of area as in the common practice with oriental tobacco. In these tests were employed representatives of three types of oriental tobacco. These were Stanimaka (Kavalla type), Ayassolouk (Smyrna type), and Broussa (Samsoun type), as well as one flue-cured type, Cash.

The experiments concerning effects of light of different intensities were performed upon both field-grown plants and plants grown under glass. Plants exposed to normal illumination were compared with those grown under artificial shade. Use was made of a shade tent built of framing and covered with seed-bed cloth to reduce light-intensity, and comparative light measurements were made with a Weston photometer.

INHERITANCE AND GLANDULAR HAIRS OF TOBACCO

There exists a rather meagre background of observations on inheritance of pubescence or hair-coatings among plants. Paulesco in 1900 (vide Netolitsky 1932, p. 11, 12) was among the earliest investigators to show that the hair pattern of hybrids is a mixture of that of both parents. A similar conclusion was reached by Wolf from observations on *Potentilla*, by Netolitsky on *Rubus*, and by Baros on *Verbascum* (Netolitsky l.c.). Imai (1926) crossed a smooth-stemmed morning glory, *Ipomoea hederacea* Jacq. (*Pharbites Nil* Choisy), with a hairy-stemmed one. All plants of the F_1 generation were hairy but in the F_2 generation a ratio of 3 : 1 of hairy-stemmed to smooth-stemmed individuals was obtained. A similar dominance of hairiness over glabrousness in sesame, *Sesamum indicum* L., to give a 3 : 1 ratio in the F_2 generation, was reported by Langham (1945).

The population density and length of hairs on *Hyocyamus niger* L. are at least partly determined genotypically, according to Goddyn (1926).

As regards tobacco, previous observations (Bentley & Wolf 1945) showed

TABLE 1. *Results of Selection as a Means of Increasing Hairiness*

Year	Increase in leaf area, cm.^{2}, of selected over non-selected, %	Increase in number of hairs per leaf, of selected over non-selected, %	Increase in number of hairs per unit area of selected over non-selected, %
1944	34	31	1
1945	23	38	12

the existence of varietal differences in hairiness and indicated that tests should be conducted to determine the possibility of increasing hairiness by selection. Accordingly selections were made, using the varieties Broussa, Dere, Djebel, Hendek, Katarini, and Yenidge. The average composite results, expressed as percentage differences between selected and non-selected plants, are shown in table 1.

These data do not reveal actual differences but are comparative, and show that selection provides a means of increasing hairiness. They give no indication however of seasonal effects. It should be indicated that the 1945 season was one having very excessive rainfall and an unusual proportion of overcast days. Seasonal effects become apparent when it is pointed out that an average leaf of progeny of selected plants of the varieties mentioned above bore 74 per cent as many hairs in 1945 as in 1944. An average leaf of the progeny of non-selected plants of the varieties Ayassolouk, Ghimpati, Jalomita, Stanimaka, and Xanthi-Yaka bore 60 per cent as many hairs in 1945 as did non-selected plants of these same varieties in 1944. This difference of 14 per cent seems ascribable to selection. It must be appreciated however, in the light of other experiments and of observations extending over three sasons, that, in selecting seed-stocks, account must be taken not only of seasonal influences but of the interrelation and interdependence of vigor, date of maturity, and leafiness of plants, together with leaf size, and hair population per unit of leaf surface.

The influence of selection among hybrids was sought by making selections of the F_2 generation and then comparing the progeny of selected and non-selected stocks. The hybrids involved Yenidge as the pistillate parent,

TABLE 2. *Results of Selection of Parent Stock among F_2 Generation on Hairiness of Progeny*

Year	Parents	Relative leaf size, F_2	Relative number hairs per leaf, in thousands	Relative number hairs per cm.^{2}
1945	Yenidge ♀ × Stanimaka ♂	Selected: non-selected = 80.6: 100	Selected: non-selected = 112: 100	Selected: non-selected = 129: 100
1945	Yenidge ♀ × Ayassolouk ♂	Selected: non-selected = 89: 100	Selected: non-selected = 105: 100	Selected: non-selected = 114: 100

and Stanimaka, in one case, and Ayassolouk, in the other, as the staminate parent. The results are assembled in table 2.

It is quite evident that the progeny of the more hairy parents was in turn the more hairy, results entirely in accord with well established findings on other genera of plants. The extent to which selection and hybridization can be employed, however, in actual field practice, to improve quality, can be known with finality only by extensive comparative trials, and appraisal of the tobaccos grown must be made after they have been fully aged.

SPACING

Bentley & Wolf (1945) have studied the relation between spacing and hairiness, using one oriental variety, a Burley type, and a flue-cured tobacco. The results were recorded as differences in leaf size and total leaf area of an average plant, and also as differences in number of hairs per plant, per leaf, and per unit of leaf surface.

In all studies, by other investigators, involving the effects of spacing on growth of the tobacco plant it appears that the primary consideration in appraisal of results has been "yield per acre." Although yield is a most important practical consideration, largest yield is not necessarily correlated with best quality. In fact, there is reason to believe that quality, in some tobacco-growing areas, has been sacrificed in favor of quantity. This would indicate that in experimental studies of spacing the objective should be to produce the largest possible yield and having the largest proportion of the superior grades.

Although a rationale for proper spacing no doubt exists it seems never to have been sought or established. With the idea of seeking to establish such basis for proper spacing practices, two experiments were performed during the past season. The one was essentially a repetition of a test made in 1944, except that it involved different varieties of tobacco, and the other involved further intensification of competition between plants.

In the first experiment the interval between widely spaced plants was 24 inches in 48-inch rows, and those between closely spaced ones was 5½ inches in 20-inch rows. The oriental varieties chosen were Ayassolouk and Broussa, and Cash was the flue-cured variety used. Data on average analyses of five plants of each kind are assembled in table 3.

Under these conditions the widely spaced plants had the larger leaves with the larger number of hairs per leaf. Moreover the population of hairs was less dense on widely spaced plants than on closely spaced ones, except in Stanimaka. An interpretation of data to be presented later (table 5) appears to be applicable in explaining these findings with Stanimaka. The degree of accordance with results from a similar experiment conducted in 1944 (table 4 of a previous report) is best shown by comparing the data as arranged in the accompanying tabulation (table 4).

TABLE 3. *Spacing and Hairiness of Entire Plants*

Variety	Spacing	Average total leaf area per plant, cm.^{2}	Average total hair population, per plant, on lower leaf surface, in thousands	Average size of leaves, cm.^{2}	Average number of hairs per leaf on lower leaf surface, in thousands	Average number of hairs per cm.^{2} on lower leaf surface, in thousands
Ayassolouk	Widely spaced	9,139	9,811	268.9	289.6	1.07
	Closely spaced	2,518	5,305	90.4	168.4	1.86
Broussa	Widely spaced	7,722	11,216	257.9	377.6	1.42
	Closely spaced	4,136	7,535	141.4	256.8	1.81
Stanimaka	Widely spaced	11,361	11,057	408.1	401.1	0.98
	Closely spaced	6,027	5,983	195.5	195.1	1.00
Cash	Widely spaced	11,053	12,587	516.6	588.3	1.12
	Closely spaced	3,257	7,258	158.1	352.0	2.22

To prepare table 4 an average number was first obtained for comparable structures of widely spaced and closely spaced plants. This number for the latter kind, divided by that for the former, yielded the percentage relationships recorded. When thus presented, the magnitude of differences between closely spaced and widely spaced plants is found to be of the same order each year. The data show that the closely spaced plants had approximately 40 per cent as much leaf area as widely spaced ones and 60 per cent as many hairs, but there were from 30 to 50 per cent more hairs per unit of leaf surface.

A second experiment, involving further intensification of competition, was devised to seek a reason for these differences in response to spacing. In

TABLE 4. *Comparative Effects of Spacing. Trials in 1944 and 1945.*
(Data on widely spaced plants regarded as 100)

Structures compared	Year	
	1944	1945
Proportionate leaf area of closely spaced to widely spaced plants	45.6	40.5
Proportionate total hair population per plant of closely spaced to widely spaced plants	61.2	58.3
Proportionate leaf size of closely spaced to widely spaced plants	48.4	40.4
Proportionate hair population per leaf of closely spaced to widely spaced plants	59.9	57.2
Proportionate density of hairs per cm.^{2} of closely spaced to widely spaced plants	130.1	149.5

this instance each variety was spaced as in the previous experiment and in addition each variety was so planted as to have approximately twice as many plants per length of row as occurred in the closely spaced rows. Leaves from the median stalk region were taken for analysis, and average results for the three spacings are presented in table 5.

The most noteworthy features in table 5 for each variety are: (1) that the plants, spaced most closely, have the smallest leaf area and bear the smallest number of hairs; (2) that the smallest leaves do not have the densest hair population; and (3) that each variety responds to competition to a different extent. These results indicate that an optimum spacing interval "between rows" and "within the rows" exists, and should be sought experimentally for each variety. These intervals are determinable only from results of series of trials, and hairiness and correlated leaf size may be used as a basis of judgment. It cannot be too strongly emphasized that per unit area population of hairs and leaf area must be considered as a unit in such trials. Were this done it should show that both yield and quality are optimum when the plants are suitably spaced. To space the plants more widely that optimum might be expected to increase yield at the sacrifice of quality or to space them more closely might adversely impair both yield and quality. Should these conclusions be verified by future extensive field trials, then hairiness constitutes a criterion for appraising a balance in the growing plant between quality and yield. Moreover the investigator then has, for the first time, a means for determining under what conditions optimum hairiness may be produced.

TABLE 5. *Effect of Spacing on Leaf Size and Hairiness*

Variety	Spacing, inches	Average leaf area, cm.^{2}	Average number of hairs per leaf in thousands	Average number of hairs per cm.,^{2} in thousands
Ayassolouk	48 × 24	372.6	293.8	0.79
	20 × 5½	148.8	169.6	1.15
	20 × 3	89.9	94.6	1.05
Broussa	48 × 24	348.0	427.6	1.20
	20 × 5½	187.9	235.4	1.24
	20 × 3	90.5	104.6	1.15
Cash	48 × 24	550.4	483.5	0.87
	20 × 5½	210.8	350.0	1.63
	20 × 3	124.1	190.1	1.53

In the foregoing experiment, there was a detectable difference in kind of aroma, as measured by the sense of smell, among the leaves of each variety when differently spaced. It may be assumed that each of the factors entering into the complex called spacing operates to modify not only population density of glandular hairs, but at the same time the amount and kind of material synthesized by the glands. The net result should be differences in proportion of ethereal oils produced, and hence in differences in quality of aroma.

LIGHT

That hairiness varies in response to differences in light and moisture is a general observation, known by many of the older students of plants. De Candolle (1841) concluded that "non-glandular hairs are, in general, rare in plants which grow in the shade, or in rich and moist places" and "are more abundant, generally, in those which grow in warm and dry places, much exposed to the sun." Vesque and Viet (1881) showed that the number and length of hairs on leaves is increased by the stimulus of light and of dry air. Mer (1883) also concluded that exposure to light and dryness favors increase in hairiness.

Yapp (1912), from observations on *Spirea ulmaria* L., concluded that "(b) On the erect flowering shoots of adult plants there is a regular succession of glabrous, partially hairy, and completely hairy leaves. The earliest radical spring leaves are glabrous, the cauline leaves hairy. (c) The non-flowering shoots of adult plants produce only radical leaves. The earliest of these are glabrous. Subsequently, the successive leaves exhibit increasing hairiness up to June or July, after which they are decreasingly hairy, till finally glabrous leaves are once again produced in autumn . . . seasonal periodicity in the production of hairs is a widespread phenomenon." He regards increased hairiness as a xeromorphic response, i.e., the result of factors or conditions that impose on the plant a need for increased economy of water. There are those who would question these interpretations by Yapp.

From perusal of pertinent reports of ecological investigations one is forced to conclude that there exists a paucity of experimentation on the extent to which hairiness is modified by environment and how hair-coatings, in turn, modify plant activities. That hair-coatings decrease water loss appreciably was brought into question by Sayre (1920). He removed the hairs (non-living and non-glandular) from mullein, *Verbascum thapsus* L., and then exposed one set of these plants to light and wind and another to light and still air, finding that there were no marked differences in water loss. The reason assigned by him for this lack of dissimilarity is that amount of water lost through the cuticle is small in comparison with that lost from internal tissue (mesophyll).

The present field experiments bearing on the influence of light involved comparison of artificially shaded plants with those grown fully exposed to normal illumination. The light intensity under the artificial shade was reduced from 40 to 60 per cent, as measured with a photometer. Comparative data obtained from analyses of leaves of these two groups of plants are shown in table 6.

TABLE 6. *Comparative Effects of Artificial Shade and Normal Illumination on Hairiness*

Variety	Average leaf area, cm.^{2}		Hairs per leaf, in thousands		Hairs per cm.^{2}	
	Shaded	Not shaded	Shaded	Not shaded	Shaded	Not shaded
Ayassolouk	130.5	148.8	112.2	169.6	860	1150
Broussa	128.8	187.9	135.3	235.4	1050	1240
Cash	134.2	210.8	214.7	350.0	1600	1630

It may be seen from table 6 that the leaves of shaded plants were smaller and had fewer hairs, although the population of hairs per unit area was larger than on the non-shaded plants. Actually the leaves of shaded plants were approximately two-thirds as large as those in full light, and the hairs were about three-fifths as numerous, whereas the population density of hairs was about 10 per cent greater than that of the plants in full sunlight.

Since shade-grown leaves of many species are known to be larger than those grown in full light it was anticipated that the shaded leaves would have been the larger. Both intensity and total amount of light available to these closely spaced plants may have been insufficient, and therefore the unexpected outcome may be attributable properly to inadequacy of light. Be that as it may, the results are in accord with previous studies in showing that decreased illumination may decrease the total hair population per leaf.

In another experiment comparison was made of hairiness of field-grown Katarini tobacco leaves, developed in early summer, with that of sucker leaves that developed on stubbles during the latter part of the growing season. Comparison was also made, using the same variety, of hairiness on leaves that developed on suckers from stubbles transplanted into the greenhouse in late summer. One set was exposed to normal greenhouse light and intensity of light for the other set was reduced approximately 75 per cent

TABLE 7. *Effects of Light on Hairiness of Leaves of Katarini Tobacco*

Growth conditions	Average leaf area, cm.^{2}	Average number of hairs per leaf, in thousands	Average number of hairs per cm.^{2}
Field grown, during summer	192.0	170.8	890
Suckers (field grown) arising from stubbles in late summer	83.2	123.1	1360
Suckers arising from stubbles transplanted into greenhouse. Full light	93.3	84.3	904
Suckers arising from stubbles transplanted into greenhouse. Light reduced by shade tent	92.3	64.1	695

by a cloth-covered shade tent. The comparative measurements from this experiment are given in table 7.

The most significant features in table 7 are those dealing with differences in average total number of hairs per leaf. The leaves of field-grown suckers had approximately 70 per cent as many hairs as did leaves grown during early summer. Moreover, the leaves on suckers grown under full exposure to light in the greenhouse had about 70 per cent as many hairs as did those of sucker growth in the field, and the leaves of suckers under the screen in the greenhouse showed marked further reduction in hairiness.

Since reduction in hairiness of tobacco leaves occurred in all cases in which light intensity was reduced, it is concluded that light may be made to function as the dominant factor in modifying hairiness.

GENERAL CONSIDERATIONS

The fact that a knowledge of hairiness of tobacco leaves may be employed to evaluate aroma becomes significant in the light of evidence that both quantity and quality of aroma are controllable and modifiable to a considerable degree. There is reason to believe that varieties of tobacco having aroma superior to that of varieties now in hand can be developed by selection and hybridization. Support for this belief arises from the fact that several kinds have already been made more uniform by selection, and these selected strains have shown themselves superior in vigor, leafiness, and leaf size. They are, at the same time, more hairy than progeny of non-selected stocks and it seems highly probable that they will prove to be more aromatic. Additional support for anticipating that continued improvement in kinds of tobacco can be effected stems from results of genetic studies with other species of plants. Such studies in their entirety contain nothing to counterindicate the possibility of further improving the aromatic potentialities of oriental varieties of tobacco.

The experiments thus far conducted are in accord in showing that tobacco plants produce leaves differing in hairiness as a response to differences in spacing and to differences in nutrients. Observations with other kinds of plants provide additional support for the existence of such relationship of responses to environment. Raunkiaer (1934), for example, noted that very hairy-stemmed rye plants occurred more frequently in portions of the field having the drier soils. Moreover the least hairy plants ripened appreciably earlier than the densely hairy ones. As previously noted, hairiness and maturity in tobacco seem to be similarly correlated. Again, Kisser (1927) found that hairiness of wheat is modified by the presence of certain salts. Plants, in solution culture, supplied with Ca, Mg, or Na were less hairy than those supplied with distilled water only. It would seem to follow, since hairiness, and hence aroma, can be changed by spacing and by nutrition, that hair analyses should be employable to determine proper practices of spacing and of application of fertilizers for oriental tobaccos.

It may be presumed that there exists a relationship of moisture to hairiness and a study of this factor was planned. However, periods of stress from lack of moisture did not occur in 1945, but instead the abundant rainfall throughout the growing period provided almost continuously an excess of water.

Establistment of the fact that genetic and environmental factors control volume of aroma is of coordinate importance with determination of whether quality of aroma is at the same time also controllable. One might assume that quantity and quality of aroma are inseparably correlated, at least within certain intensity or volume ranges, and hence an analysis of hairiness might be expected to serve indirectly as a measure of quality of aroma. Support for this assumption stems from the fact that, to date, from spacing trials, it has been possible to detect differences in odor between the leaves of one and the same variety when the plants were grown differently spaced. The possibility that such differences in quality of aroma could exist may best be appreciated by recalling that the odors are constituted of a complex mixture of ethereal oils. According to Brüchner (1936), these ethereal oils are aldehydes, ketones, esters, and acids of various kinds and their cleavage products, all separable from tobacco leaves by steam distillation. During such distillation the resins, which are high molecular polymers, are cleaved to liberate various volatile oils. Even if one assumes that all varieties of tobacco elaborate the same complement of chemical entities, an unwarranted assumption but one that remains to be ascertained, it seems possible that variation in spacing, nutrition, moisture, light, or other factors might induce differences in the proportion of materials synthesized, and thereby cause the aromas to be different. Convincing proof of this remains wanting, however, because there are no suitable methods for measuring quality of aroma. Such lack constitutes a serious handicap in attempts to improve varieties of tobacco and in measuring responses to different environments. Attention might well be given, as a next step, to improvisation of methods to analyze quality of aroma.

SUMMARY

Studies involving hairiness of tobacco have been continued. The results show that hairiness can be increased by hybridization and/or selection. Additional evidence has been secured that hairiness is modified in response to spacing practices and in response to light. These findings indicate (1) that, to a degree, both the volume and quality of aroma are controllable; (2) that all varieties of oriental tobacco may not produce tobacco of largest yield and best quality if spaced alike; (3) that analysis of hairiness seems to provide a means of determining proper spacing and fertilizer practices.

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ON THE USE OF ARTIFICIAL HEAT IN THE PREPARATION OF HERBARIUM SPECIMENS

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The perennial discussion of "naturally dried" vs. "heat-dried" specimens has been recently revived by Professor Fernald (Rhodora **47**: 258–260. 1945); his arguments are reinforced by included comments by Bayard Long. From the combined texts the main objections to the drying of specimens by artificial heat seem to be (1) the loss of any glaucescence which might be present, (2) their greater likelihood to fracture and fragment, and (3) a more than implied tendency by users of the artificial method to hurry the material through the drying process and so fail to obtain specimens which are satisfactorily arranged on the sheet.

As a confirmed user of the "artificial" method I must bow to the accusation that specimens with just those unfortunate drawbacks *can* be so produced. However, it is possible either to avoid or overrule these objections to a large extent.

Regarding the first one—that of loss of glaucescence—there is but little that can be done about it. Having some slight experience with a group of plants (the Vacciniaceae) where the item of glaucescence is of considerable importance, it has been my experience that, no matter whether the "artificial" or "natural" method is used, I still cannot rely with surety on the character in the dried state since, in this group, the glaucescence is the result of an oil-air-emulsion and usually is easily lost by the mildest of abrasions either during collection or in press. It is obvious that the use of specimens over a period of time also tends to dim this character—at least in the blueberries—and so I have deemed it best to rely almost entirely on notes taken in the field. It would seem then that, for at least some groups, the objection raised by Professor Fernald that the drying of specimens by artificial heat does not permit him to make certain identifications might quite as well be critically directed at the field habits of collectors themselves as with their method of drying the plants.

As an example, I have close at hand a packet of specimens which I am checking—specimens for the most part made by well-known collectors. In making a selection from this packet care was taken only to ascertain that the specimens had been collected by those who were botanists (and for the greater part taxonomists) and therefore *ought* to know the problems confronting the systematist. On each of these sheets there is a ticket explaining in considerable detail exactly where the material was collected—data usually so excellent that one could return to the exact locality and recollect the material if so desired. However, on not a single one of these is there the slightest indication by collector's notes whether the material was a tree or shrub (being of the genus *Vaccinium* one can only trust that they were shrubs); nor is there any note concerning the type of plant—i.e., whether solitary or in clumps (clon-forming). Naturally, with those omissions, one scarcely would expect that items such as the relative glaucescence of the upper and lower surface of the leaves or the glaucescence of the fruit would be recorded, but one might logically expect that at least some mention could have been made of the color of the flowers or mature fruit (all of which are of considerable importance in the systematics of this group). However, the greatest lack apparent on these tickets is that of height of plant. Of these specimens (and I repeat, they were taken more or less at random—the first dozen or so which came to hand in the parcel nearest me) only 1 records this item of plant height, an item often extremely useful in classification.

As Long notes in his personal communication as printed by Fernald, "Of course it [artificial drying] saves 'busy' men much labor but it produces a very unsatisfactory grade of specimens." Fernald then continues under his own momentum: "It is evident that we must remember the old saying, that 'haste makes waste.' " One can but be curious whether the collectors of these specimens (well known for their use of the "natural method") might not have been so "busy" changing blotters, running in and out between showers trying to dry them, and occupied with the other myriad of similar chores attendant to their favorite system of specimen preparation, that they had no time while in the field to jot down what might reasonably be thought of as a minimum of data concerning the habits and characters of the living plants. Possibly in their attempt to achieve "pretty" specimens they could not be bothered with one of the really basic elements of taxonomic study—that of a set of effective field notes. One wonders if instead of "haste makes waste" it might not be otherwise—a case of "borrowing from Peter to pay Paul"?

It would therefore seem that a method of handling specimens in the field which liberates the collector from the tedium of changing blotters ought to be welcomed, one giving him more time to study the material in the fresh state, sufficient at least to record adequate notes. So far as the objection that artificial drying destroys glaucescence is concerned, it might well be disregarded. It would seem that the character of glaucescence ought to be recorded along with such items as flower or fruit color, as well as the height and habit of the plant.

Now for the objection that artificial drying makes the plants brittle. It is a true and certainly valid objection if the material is not properly handled before being put on the heat. In his first paragraph Professor Fernald—and quite rightly—points out the proper procedure. Except in emergency cases or with certain materials, the specimens should stay between blotters for a full 24 hours before being placed between the corrugates and on the heat. So far as I know no actual research has been done on this item, but there is no doubt that, generally, the results are much better if the "sweating" period is carefully attended to; the result is specimens which usually are quite as flexible and rarely more brittle than those naturally dried. It would seem that during the "sweating" process—and because of the exclusion of air in the press—there is a slightly modified form of anaerobic oxidation within the plant tissues so that instead of the more common oxidation of the carbohydrates at least slightly greater amounts than usual are changed to fatty compounds and that it is these substances which, slightly diffused through the tissues, lend a certain pliability to the completely dried specimen. While this statement is certainly in the realm of speculation the net result does indicate the advisability of the "sweating" process prior to drying by artificial heat.

Nevertheless, even after due care is taken with the sweating, there yet is danger that the heat becomes so great that it leaves the specimens brittle. Again, it is my opinion that excess heat drives off these fatty compounds by distillation and that herein lies the danger rather than in the use of "artificial" methods. When a press over the heat source is too hot for the hand it is too hot for the specimens. Certainly a "rule of thumb" but nonetheless effective.

The third objection—voiced by Mr. Long—is that "They [the specimens] get dried without even being examined again (while green and fresh) and, of course, there is no opportunity (if desire) to straighten leaves, draw flowers or fruit into view, or any of the other desirable "fixing" which results in good specimens." It is obvious that if the specimens are placed directly over the heat there would be no opportunity to arrange them. But one might ask: Just how often is it necessary to paw over a specimen before it is properly arranged? If the program suggested by Professor Fernald (and agreed with in completeness by me) were followed, it would seem that ample opportunity would be afforded for a preliminary arranging of the specimen as it was first placed in press and also for a final inspection and "fixing" after the "sweating" process is complete and just before being placed in position for drying. It is a rare specimen indeed which at the end of a 24-hour period of "sweating" is not sufficiently "tamed" that its parts will not lie in place when arranged for the final drying.

Having but recently returned from a trip into one of the moister parts of South America, I feel perhaps somewhat qualified to mention certain items relative to the problems of collecting under conditions which possibly would not be classified as the most ideal. I trust that this personal reference will be pardoned, but the figures are at hand and the situation available from my notes and memory. It will suffice, therefore, to say that from the latter part of July to the first part of September, 1945, my two local Cholo helpers and I were in the Cordillera Oriental of Ecuador working from about 7,500 feet up to elevations of approximately 11,500 feet. At best the trails were poor; sometimes they were non-existent, in such instances necessitating the slow and laborious cutting of paths, often through dense thickets of *Chusquea* (the bamboo-grass so characteristic at these altitudes). It is a region where the annual precipitation may equal—or even exceed—200 inches; also, it was the height of the rainy season. Those who have worked at the higher elevations in the wetter parts of the Andes will understand the conditions under which we labored without further expansion of this topic. It might also be added that we were in a zone which, so far as I am aware, had never before been systematically collected.

During the 41 days we were in that particular zone only two or three were sufficiently sunny so that blotters could have been dried and on the great majority the sun did not show at all; most of the days it just rained. Yet in spite of this our little group returned from this particular area with more than 6,600 sheets of herbarium material in about 1,000 numbers. These figures are not given in a spirit of boasting, for it doubtless has been far exceeded by others in a like period. But of this I am quite certain: had we relied on the natural method of drying by means only of blotters, our haul from this area would have been numbered in the hundreds instead of thousands.

We used kerosene stoves as a heat source and there were times when, with materials jamming the presses, it was necessary to place certain specimens directly on the fire without the necessary preliminary "sweating" so as to keep the collections rolling and the drying process and stoves working at maximum efficiency. Much as I regret the fact that certain of these collections might not make quite so satisfactory specimens as one would like, other factors overbalanced that item. Considering the extent of our ignorance of the flora in that region, it would seem from the standpoint of the working taxonomist that a specimen, "*in herb.*" and with duplicates (even if slightly brittle and possibly with not all the leaves properly placed on the sheet) is worth considerably more than a whole mountainside of the same species as yet uncollected.

Another of the arguments against the use of artificial heat and the necessary corrugates in drying is that they tend to produce parallel ridges on the specimens. In certain cases and with particular materials, this is true. But I always have had the feeling that it is much better to work with a slightly corrugated specimen which was properly dried than one in which the flower parts had become heavily infested with fungi or eaten by larvae already present in the material when collected—an ever-present danger in the much slower process where only a series of blotters is used, and a double danger under tropical conditions in the rainy season. It is also true—and especially so at certain seasons and while working with primarily woody forms such as one encounters in tropical regions (and a crying fault of many autumnal collections of woody materials in the temperate zone)—that too-long a wait in the "sweating" process accelerates the production of the abscission layer so that, although the parts have been quite prettily arranged, they promptly fall off, leaving only a bare stem and a hand full of loose leaves and flowers or fruit. The only remedy for such types under ordinary field conditions is to put them on the heat and dry them out as quickly as possible—and before the abscission layer has had time to fully form. Therefore where large "mushy" flowers are concerned as well as those in large and complicated clusters and so often subject to larval depredations while in the fresh and semi-fresh conditions, as well as those groups especially prone to dropping their leaves, it most certainly is not true that "haste makes waste." There are times when haste is the only method whereby material may be obtained in anything approaching a satisfactory condition. The desiccated start of a fungus culture, a larva killed by heat, or an incompletely formed abscission layer, are not feared by the collector; uncontrolled by prompt action, they result in nearly useless specimens.

In his introductory sentence Professor Fernald mentions the use of "corrugated pasteboard" thereby passing by what one might suppose would cause him even more alarm—the present vogue for the use of metal corrugates. Having used all methods—blotters only, corrugated pasteboard with double facing, single-faced paper corrugates as well as several styles of metal corrugates—I have come to the conclusion that, by and large, the metal corrugates lend themselves to the problem of extensive collecting better than any other.

In the first place—and I would make it clear that the following remarks apply primarily to "expedition collecting" in regions and at seasons where the humidity is high—the blotter method can be excluded on the following counts: (1) It consumes time which might better be spent both in the field and in the assembling of adequate notes; (2) there is too much danger of spoilage by fungi and minute larvae (the application of an alcohol-formaldehyde solution is, in my opinion, only an emergency measure at best); and (3) even if conditions were such that blotters could be used, the factor of bulk still would rule them out. Where supplies must be carried by plane, by canoe, by mule, or even at times on the backs of men, both bulk and weight are very considerable items and add materially to the expense of collecting.

As far as double-faced corrugated pasteboard is concerned it does have certain advantages where one wishes to speed up the drying process to a considerable extent. But where the corrugates must be used repeatedly the openings tend to close up all too quickly and so the whole reason for using them is defeated. Unless the ducts are fully open, permitting a rapid desiccation, the specimens tend merely to "stew in their own juices" and so *do become brittle* after ultimate drying. I have long had the opinion that many of the criticisms leveled at the drying of specimens by the use of corrugates actually stemmed from this failure of the process rather than from the use of artificial heat. Besides the fault that the double-faced corrugates all too soon become worse than useless, they also are quite uneconomical of space and bulk too much in the baggage.

While the single-faced paper corrugates occupy much less space than the double-faced ones (because they can be "nested") and are therefore more to be desired, they also have the failing of ultimately breaking down and becoming useless. However, in the long run, I prefer them to the double-faced type. This is especially true if transportation is not too great an item, but only if a completely adequate supply can be carried along. One of the problems confronting the collector in regions where supplies are not readily available is that of material for packing the bundles of dried specimens. Although the single-faced corrugated pasteboard has a life-span which is not overly great, yet with careful use and a little planing it reaches the end of its usefulness in the drying press about as fast as one has need of reinforcing for the bundles; thus, having outlived its usefulness as a drier, it next becomes useful in wrapping and protecting the already dried specimens. For ordinary collecting one can expect to consume about 100 corrugates per 1,000 specimens; that is, a single-faced corrugate can be used about ten times. It is to be admitted that during the last half of its life it is not nearly so effective as when new. This also increases the time on the fire and therefore adds to the danger of overheating the specimens while still wet; it also increases the amount of fuel needed to complete the drying process, certainly an item which cannot be ignored.

This brings us to the metal corrugates. They have two great advantages. The first is that with any reasonable care their life-span is indefinite. The second is that although unit for unit they weigh considerably more than cardboard corrugates, the total weight of a set of metal ones needed for even a moderate trip is considerably less than that of cardboard ones necessary for a like amount of specimens. The problem of wrapping the dried material is still with the collector, but it has been my experience that a roll of heavy wrapping paper (preferably the type used by nurserymen to wrap plants—double-faced with a thin layer of tar between) serves quite as well as the ultimately flimsy corrugates and has the added advantage of being both waterproof and (because of the tar) insect-repellant. Furthermore, when one uses metal corrugates, they can be forgotten while moving the scene of operations. One has enough to worry about while moving about, what with seeing that the food, the equipment, and specimens already collected are snug and dry. Accidents can and will happen: cases of equipment have been left out on docks in some port during the rainy season, a box can be dropped out of the canoe as it is being unloaded, a carrier can slip while crossing a stream and fall with his load, or a careless mule driver may not have taken sufficient care with his cargo cover during a long trek in the rain. With metal ones the collector never has the sorry experience of opening a packing case expecting to find corrugates, only to find a useless pulpy mass instead.

It is to be admitted that, because of their lower pliability, the metal corrugates tend less to follow the contours of the specimens than do the paper ones and so may cause some secondary corrugation of the specimen. But with a slight amount of practice the drying presses can be so packed that this item usually causes but little trouble. If one starts correctly in the beginning of the pressing process, laying the butts or thicker parts of the material in rotation in the different corners, this will carry right through to the drying press; and it is surprising how little trouble is encountered and how even the press will be.[1] It is true that in flimsy-textured materials a slight amount of residual corrugation of the specimen may occur. But it is just such materials which cause the greatest trouble under tropical conditions. Again, it should be pointed out that there are those who would rather work with a specimen intact but which has a few minor and scarcely visible corrugations on it than one which had become half-rotted and all but buried on a mat of fungal hyphae in the drying process.

In my own use of metal corrugates I have come to the conclusion that the most efficient order of packing in the drying press is as follows: corrugate—specimen in folded newspaper—blotter—specimen in folded newspaper—corrugate; etc. In the first part of the process over the heat the press may be so placed that the newspapers open downward; toward the end the presses should be reversed so that the crease in the paper is at the bottom, thereby making certain that no odd fragments (extra flowers included for dissection, etc.) can fall into the fire and so be lost or perhaps cause a slight burst of flame which, under certain conditions, might cause a blaze. With particularly tender materials, perhaps some special specimen with an unusual flower cluster or possibly some item of extreme interest with the flower parts already dissected and laid open, the order in the press might be slightly different: corrugate—blotter—specimen in folded newspaper—blotter—corrugate.

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[1] In passing it might be noted that the same principle applies to the mounting of herbarium specimens. While the individual specimen may look better mounted in the "classical manner" as advocated in certain places—with the label at the lower right corner (where it ought to be) and the stem-butt at the lower left—a constant rotation of the position of the bulky parts of the specimen in the long run will keep the sheets more or less level on the herbarium shelves and so avoid the "cascades" of sheets and "camel-backed" covers which one sometimes encounters. It is obvious that if this is done in the mounting room there is chance that a few pigeon holes will cause some trouble, but the law of averages usually holds the specimens on an even keel. In certain woody groups the saving in herbarium space is as much as 15 per cent; in extreme cases it may be almost 40 per cent.

Then there is perhaps necessary a word about the corrugates themselves. They may be made of "tin" (tin-plate), but the best of them tend to corrode and wear with use and so start rusting. Aluminum would be better; and it is likely that a little scouting among the newer of the light-weight alloys would reveal some excellent materials. A combination of lightness and tensile strength without brittleness would be ideal. So far as the size of the corrugations is concerned—and having used several types—it is my opinion that they should be about 1.5 cm. from crest to crest with a total depth of 0.5 cm. This may appear to be a little coarse to some workers, but it is my experience that if the corrugations are shallower the plant parts tend to squeeze into the "valleys" stopping up the ducts and so defeat the whole purpose of the set up. On the other hand if the distance between crests is cut to less than 1.5 cm. the surface of the edge in contact with the specimen necessarily will have to be too sharp and so tend to add to the creasing.

This problem of creasing when using corrugates of any kind—and especially with the metal ones—has been alluded to so often that I am moved to make several additional observations on their use. Custom and habit often influence our methods. Most of us began our plant pressing by using blotters, where we learned to "heave on the straps and squeeze out the water." And I have seen many a fellow collector stand on the press (sometimes even jumping up and down) while his assistant grunted over the fastenings. There is considerable sense to this procedure where blotters alone are used, for pressure does get rid of some of the water and, furthermore, an intimate contact between the plant and blotter speeds up the process of diffusion. Curiously enough, I have seen certain collectors use much the same technique when "trying out" the metal corrugates for the first time. It is not necessary; actually it is this unnecessary pressure which forces the specimen into the corrugations. not only slowing down the drying very considerably but also producing the ridging on the specimens bemoaned by so many. A firm contact between the specimen and press is all that is needed.

Naturally, it will be necessary from time to time to tighten the fastenings on the press—but that is also true of those specimens dried entirely with blotters. The trouble is that with the use of metal corrugates over even moderate heat the drying process goes on so rapidly that a collector who has not used them previously waits until the press is loose. By that time the specimens often have shriveled and already dried beyond the point where anything can be done with them. After a tough day in the "bush" and with three or four hours more spent beside a dim kerosene lantern or flickering candle checking over and possibly amplifying field notes as well as arranging the specimens collected the previous day (and which already have gone through their 24-hour period of "sweating"), it is not always a particularly easy thing to wake up two or three times during the night and crawl out from between warm blankets to check the fires and see that the press fastenings are snug, but it is part of the job. During those nocturnal chores—done almost automatically after a while—one often can hear the sibilant patter of rain on the thatch. It rained all the day before—and the chances are very good that it will rain all the next day—just as it has for so many days in succession. But no matter. The collecting keeps on and (what is more important) one knows that the specimens are being dried on schedule. For the conscientious collector there is a peculiar brand of comfort in this knowledge as he crawls back into his blankets.

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THE EVALUATION OF TAXONOMIC CHARACTERS OF CULTIVATED BRASSICA WITH A KEY TO SPECIES AND VARIETIES—I.

THE CHARACTERS[1]

VON GEE SUN

INTRODUCTION

A better classification of *Brassica* has long been needed. While much has been published on this genus, workers from the time of Engler and of Bailey to the present have been influenced by the demand of agricultural botanists for a satisfactory agricultural classification. The author believes that the resulting combination of botanical principles and agricultural convenience is responsible for much confusion.

The evaluation of morphological characters in conjunction with studies of genetics and cytology of interspecific hybrids has been used by the writer in making a classification based primarily on botanical principles.

It should be emphasized also that most quantitative characters have been overlooked by the taxonomist because of the difficulty of observation and a lack of standard methods for group comparison. It is easy to investigate a quantitative character by means of small sample measurements and analysis of variance. The writer applied this method to quantitative characters of different species of *Brassica* in order to evaluate them taxonomically. Because of the lack of detailed genetical studies of the genus, he has not arrived at a final conclusion on the entire taxonomic problem.

REVIEW OF LITERATURE

The more important of the older contributions to the classification of *Brassica* are those of Bailey (1922) and of Engler and Gilg (1924). Recently

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[1] Contribution from the Department of Agronomy, College of Agriculture of the National University of Chekiang, where the author is Professor of Agronomy and Director of the Agricultural Experiment Station.

This paper was originally addressed to the Botanical Review, being forwarded by the Department of State. It was sent then to the editor of the Bulletin, and by him submitted for review and criticism to Dr. H. K. Hayes of the University of Minnesota. At the instance of the latter the paper was carefully read by Dr. T. M. Currence and Dr. A. E. Hutchins of the Department of Horticulture of the same institution, who made valuable suggestions and effected some modification and condensation. Certain additional changes were made by the editor; a few figures were omitted. Because of current conditions it was obviously impractical to communicate with the author in the usual way about his paper. The editor trusts that these emendations will prove acceptable to him.

Part II, containing a discussion and the key to species and varieties, with the list of literature cited, will appear in an early issue. Publication of the figures was assisted by the Lucien Marcus Underwood Memorial Fund.

Morinaga in a series of important papers (1929a,b,c, 1931, 1933, 1934) discussed the natural species-groups of *Brassica* in the light of cytological work and indicated the principles of a classification which should be acceptable to taxonomists.

Engler and Gilg divided the Cruciferae into two main groups, as follows:

A. Hairs unbranched or none; no glandular hairs.
B. Hairs all or in part branched, only seldom lacking; glandular hairs sometimes manifest.

Under A we find the Sinapeae, characterized as follows:

Sinapeae. Stigma strongly developed over the placenta, on a capitate or 2-lobed style.

This tribe is divided as follows:

b. Cotyledons arising at the curve of the embryo.
  β. Mostly with lateral and median nectaries; fruit mostly a silique, seldom a silicle or a transversely jointed silique or indehiscent.
    II. Style 2-lobed or suppressed.
      Brassicinae. Cotyledons conduplicate; nectary present; silique sometimes transversely jointed.

Four genera, *Eruca*, *Sinapis*, *Brassica*, and *Raphanus*, were mentioned under this tribe. Five cultivated species exclusive of *Sinapis alba* were recognized in *Brassica*. These are: *B. nigra* Koch; *B. oleracea* var. *acephala* DC.; var. *gongyloides* L.; var. *gemmifera* DC.; var. *sabauda* L.; var. *capitata* L.; var. *botrytis* L.; *B. campestris* L. (= *B. rapa*) var. *annua* (summer oil seed type); var. *oleifera* (winter oil seed type); var. *rapifera* (turnip); *B. napus* L. var. *annua* (summer rape); var. *oleifera* (winter rape); var. *napobrassica*; and *B. juncea* Coss.

In the opinion of the writer the exclusion of *Sinapis alba* from *Brassica* should receive the careful attention of present workers. The classification of varieties in the *B. campestris* and *B. juncea* group also needs investigation.

Bailey (1922) described species and varieties of *Brassica* in great detail. He separated the genus by the following characters:

A. Species with fr. plainly dehiscent by 2 valves.
  B. Fr. a narrow silique, manifestly longer than broad, the septum or partition usually flatwise of the pod and as broad as the valves.
    C. Seeds in a single row or series lengthwise the pod in each compartment.
      D. Stigma simple or essentially so, and nearly or quite capitate.
        E. Plant glabrous, or if hirsute or pubescent then with simple hairs.
          F. Fls. yellow or ochroleucous.
            G. Length of fl. 1/4 in. or more; petals distinctly clawed; cotyledons conduplicate.

About 20 cultivated species were described; *Sinapis alba* was considered as a member of the genus. From an inspection of the available material, also from Bailey's original description, it can be seen that though the above-mentioned 7 key characters hold true generally for most species of the genus, character E does not seem to be applicable to *Sinapis alba*.

Bailey recognized the following characters as important in the separation of species: glaucescence of plant, size and color of flower, habit of sepals (erect or spreading), distribution of flowers on the inflorescence at anthesis, shape and length of beak, and shape of leaves. Many of his subdivisions appear to be based on leaf characters.

Pearson (1928) was the first author to suggest classifying *Brassica* on the basis of the chromosome numbers. He recognized four classes in the genus, based upon determinations of chromosome numbers; owing to Karpechenko's wrong determination of the chromosome number of *B. napus*, Pearson made no satisfactory grouping of the genus.

Nagai and Sasaoga (1930), Karpechenko (1930), and Morinaga and Fukushima (1930) made exhaustive determinations of the chromosome numbers. Their results show that there are 7 groups of numbers in the genus, which may be listed as follows:

Chromosome number	Species examined
12	*B. alba* Rabh. (*Sinapis alba* L.)
8	*B. nigra* Koch (*Sinapis nigra* L.)
9	*B. arvensis* Rabh. (*Sinapis arvensis*)
	B. oleracea DC. (all known varieties)
10	*B. campestris* L. (all known varieties)
	B. chinensis L. (many varieties)
	B. pekinensis Rupr. (many varieties)
	B. narinosa Bailey
	B. nipposinica Bailey
	B. rapa L. (many varieties)
17	*B. carinata* Braun
18	*B. juncea* Coss. (many varieties)
19	*B. napus* L. (many varieties)

The above results throw some light on the grouping of the species, but relations between species with different numbers of chromosomes remain obscure.

Morinaga in his long series of cytological investigations (1929a,b,c, 1931, 1933, 1934) of the interspecific hybrids of *Brassica* showed that three fundamental chromosome sets were present. Species having haploid numbers of 8, 9, and 10 were considered as elementary species; others were considered as amphidiploid species. Each amphidiploid was said to be derived from the combination of two elementary species. As a result of Morinaga's work, the cultivated species of *Brassica* may be classified in the 6 groups shown in table 1.

In addition to Morinaga's results, U (1935) obtained even more decisive data, which confirm much of Morinaga's views. From the cross *B. campes-*

tris × *B. oleracea*, four F_1 plants were obtained: COF_1–1, intermediate, closely resembling *B. napus* in appearance, rather sterile, having 19 somatic chromosomes and producing $(0–8)^{I} \pm (19–3)^{II}$ at meiosis; COF_1–2, more fertile, with 28 chromosomes, producing $(0–5)^{III} \pm (9–4)^{II} \pm (10–5)^{II}$; COF_1–3, also more fertile, with 29 chromosomes, producing $10^{II} \pm 9^{I}$; and COF_1–4, almost fully fertile, with 38 chromosomes, producing 19^{II} at meiosis. COF_1–4 was considered to be an experimentally produced *B. napus*, being an amphidiploid with reduplicated chromosome sets of *B. campestris* and *B. oleracea* (aacc); while COF_1–2 and COF_1–2 were triploids with reduplicated sets of *B. oleracea* and *B. campestris* respectively (acc and aac), trivalent formation in COF_1–2 being due to a slight affinity between *B. oleracea* (c) and *B. campestris* (a). The results of the crosses *B. napus* × *B. oleracea* and *B. napus* × *B. campestris* support these conclusions, meiosis in the F_1 of the former resembling that in COF_1–2 and in the latter COF_1–3, as is to be expected, if the genom of *B. napus* is what has been indicated. The F_1's of the cross *B. carinata* × *B. oleracea*, according to U, were very sterile, closely resembled the female parent, had 26 chromosomes, gave $9^{II} + 8^{I}$ at meiosis; except $CaOF_1$–2, which was completely sterile, had 35 chromosomes, and produced $(9–5)^{III} + (0–4)^{II} + (8–12)^{I}$, having a reduplicated *oleracea* set. The F_1's from *B. carinata* × *B. nigra* again resembled *B. carinata* and were highly sterile; they produced $8^{II} + 9^{I}$. These results suggest that the genom of *B. carinata* is a combination of those of *B. nigra* (b) and *B. oleracea* (c), a conclusion which is partly confirmed by the observation of $(0–6)^{III} + (9–3)^{II} + (18–12)^{I}$ in the single, fairly fertile F_1 produced from the cross *B. napus* × *B. carinata*. From the cross *B. juncea* × *B. carinata*, intermediate, partially fertile F_1 plants with 35 chromosomes were obtained, showing at meiosis $(8–16)^{II} + (19–3)^{I}$. This, in conjunction with Morinaga's results, shows that the genom of *B. juncea* is aabb.

TABLE 1. *Genomic constitution of cultivated Brassica.*

Group	*n*	Genomic constitution	Species	Remarks
I	10	aa	*B. campestris* L. *B. rapa* L. *B. chinensis* L. *B. pekinensis* Rupr. *B. japonica* Sieb.	elementary species I
II	8	bb	*B. nigra* Koch	elementary species II
III	9	cc	*B. oleracea* L. *B. alboglabra* Bailey	elementary species III
IV	18	aabb	*B. juncea* Coss. *B. cernua* Hemsl.	amphidiploid species from I and II
V	19	aacc	*B. napus* L. *B. napella* Chaix	amphidiploid species from I and III
VI	17	bbcc	*B. carinata* Braun	amphidiploid species from II and III

In general, Morinaga's and U's genomic hypothesis of *Brassica* seems well established. But the more interesting problem is the taxonomic relation of *Sinapis alba* to *Brassica*.

Sun (1942) following Bailey's system, with his own observations, has formulated a key to the species and varieties of *Brassica*, in which he treats the early maturing Chinese rape, "siao-yu-tsai," as a variety of *B. chinensis* L. and the late maturing Chinese rape, "da-yu-tsai," as a variety of *B. juncea* Coss.; two other varieties, *B. juncea* var. *linearifolia* and *B. juncea* var. *orthocarpa* were added. *B. pekinensis* Rupr. is treated as a variety of *B. chinensis*.

Tsen and Lee (1942) in a preliminary study of Chinese cultivated Brassicas, described 12 varieties under *B. juncea*, 4 under *B. chinensis*, and 3 under *B. pekinensis*. Some of these are probably synonymous, comparable with Sun's (1942) suggested names. Tsen and Lee indicate that *Sinapis* and *Brassica* should be combined.

Sun (1943a), in a study of hybrid vigor in *Brassica*, found none in the F_1 of *B. pekinensis* (Meitan variety) × *B. chinensis* var. *pandurata* Sun (Meitan siao-yu-tsai), which indicates little genetic difference between these two varieties. From an inspection of their morphological characters, it can be seen that gross difference between them is confined to the foliar organs. In foliage color, siao-yu-tsai is light green and *B. pekinensis* yellow or yellowish-green; both have winged petioles except that in siao-yu-tsai the lower part of the wing may be occasionally lobed or wanting. Radical leaves of *B. pekinensis* are orbicular or obovate in outline, with broad, flat, and white petioles; those of siao-yu-tsai are pandurate to obovate, with thin petioles. From these observations and the results of crossing, Sun suggests that *B. pekinensis* be treated as a variety under *B. chinensis*.

MATERIALS AND METHODS

When the College of Agriculture of the National University of Chekiang moved to Meitan in 1940, a number of varieties of "yu-tsai" and brassicaceous vegetable crops were introduced from various parts of South China for breeding. Morphological characters of these introductions and of local collections were examined; crosses were then made between different varieties and species in the spring of 1941. The available materials mostly belonged to the 10- and 18-chromosome species; a few to the 9-chromosome group; and only one, rutabaga, to the 19-chromosome group. Later, Professor Jin Zon Yu introduced the Japanese *B. napella* Chaix to Meitan, and the 8-, 12-, 17-, and other 19-chromosome species were furnished by Dr. H. W. Howard of Cambridge, England, in the latter part of 1942.

All materials were planted in the nursery garden in small plots, and their morphological characters recorded from seedlings to maturity. For quantitative or size characters small random samples were taken from each plot and the important characters were measured and compared by analysis of variance.

The characters are as follows:

1. Hairiness of plant.
2. Size of pollen grains.
3. Stem characters.
4. Root characters.
5. Shape of leaves.
6. Glaucescence and color of plant.
7. Branching habit.
8. Type of inflorescence at anthesis.
9. Type of sepals at anthesis.
10. Size and shape of petals.
11. Color of petals.
12. Length and shape of silique.
13. Length and shape of beak.
14. Angle between pedicels and rachis.
15. Number of seeds per silique.
16. Color and size of seeds.

Among the available materials, two may be considered as mutants. One is "tson-tsai," named by Sun (1942) *B. juncea* var. *linearifolia*. (In Tsen and Lee's paper, *urophylla* may be a synonym of this.) A description of this variety and its taxonomic and cytologic relationships with other varieties may be found in Sun and Sze's paper (1943c).

The other mutant is white-flowered "piao-er-tsai," which may suggest a similarity to Tsen and Lee's *B. chinensis* var. *rosularis*, but differs in some points. The plant is annual, dwarf, the height 2–3 feet at anthesis, the leaves dark green, nearly black, glabrous, shining or glossy, not winged, with white or greenish-white, thick and broad petioles, the leaf-blade orbicular, entire, more or less wrinkled, with one or two small ear-like lobes on the petiole just below the blade (fig. 8). The radical leaves are generally spreading on the ground. The stem-leaves are sessile, entire, usually triangular, cordate-expanded and clasping. Inflorescences are short at anthesis, approximately 18–25 mm., with flowers clustered at the tip. The petals are white, though at the point of inflection of the claw a very light yellow color is evident; the petal is 10–12 mm. long, 7–9 mm. wide; the sepals are separate and the pedicels spreading; the silique is short, 18–24 mm. long, the mean 20.2 mm.; the beak is 4–6 mm. long. The seeds are small and reddish-brown. Natural fertility is low. Crosses were made between white-flowered piao-er-tsai and other varieties of *B. chinensis* in order to study some of its mutant characters.

Besides these new types, individuals were found in both the *chinensis* and *juncea* groups with white (very light yellow) petals. These were selfed and crossed with normal yellow-petaled plants to study their genetic origin.

OBSERVATION OF CHARACTERS

A source of much confusion in earlier work has been the occurrence in *Brassica* of simply inherited characters with large individual effects. By virtue of a difference in one or two such characters, plants have been confidently classified in different species. A genetic study of the genus, however, immediately reveals the deceptive nature of such differences and leads to the discovery of specific distinctions based on differences in the hereditary make-up as a whole rather than on differences in particular characters. In devising a satisfactory classification it is necessary to use only such characters as are indicative of fundamental differences in genetic constitution; the value of the more important characters for this purpose will now be discussed.

It has been pointed out that six chromosome numbers occur in the genus. Such differences are well known as a basis of classification, e.g., in *Triticum, Avena, Hordeum, Gossypium, Nicotiana*, and *Datura*.

1. Size of Pollen Grains. As a result of experiments in the last two years, the writer (1943a) has reported that *Brassica* may be divided into two groups according to size of pollen. The large-pollen group includes species with $n = 18$ and $n = 19$; its mean pollen length ranges from 41 to 47 μ and the mean product of length × width from 1179 to 1541 μ^2. The small-pollen group includes species with $n = 9$ and $n = 10$; its mean pollen length ranges from 33 to 40 μ and the mean product of length × width from 735 to 1080 μ^2. Judging from the general appearance of species within each group, the writer has pointed out that the 9-chromosome are quite different from the 10-chromosome species, and the 18-chromosome very different from the 19-chromosome species. Actually the 19-chromosome are rather closely related to the 9-chromosome species, and the 18-chromosome to the 10-chromosome. The pollen size, therefore, cannot be regarded as a principal taxonomic character and should be considered only as of secondary importance.

In the spring of 1943, examination of pollen size of the newly introduced species was undertaken by Mr. S. S. Koo (Instructor in Agronomy in this University). Species examined included *B. nigra, B. campestris, B. carinata, B. napus,* and *Sinapis alba* of Dr. Howard; *B. napella* of Professor Yu; and the local material *B. chinensis* var. *pandurata* and *B. juncea* var. *orthocarpa.* Twenty measurements were made for each species. The mean pollen length and width are shown in table 2. The differences necessary for significance were determined by analysis of variance.

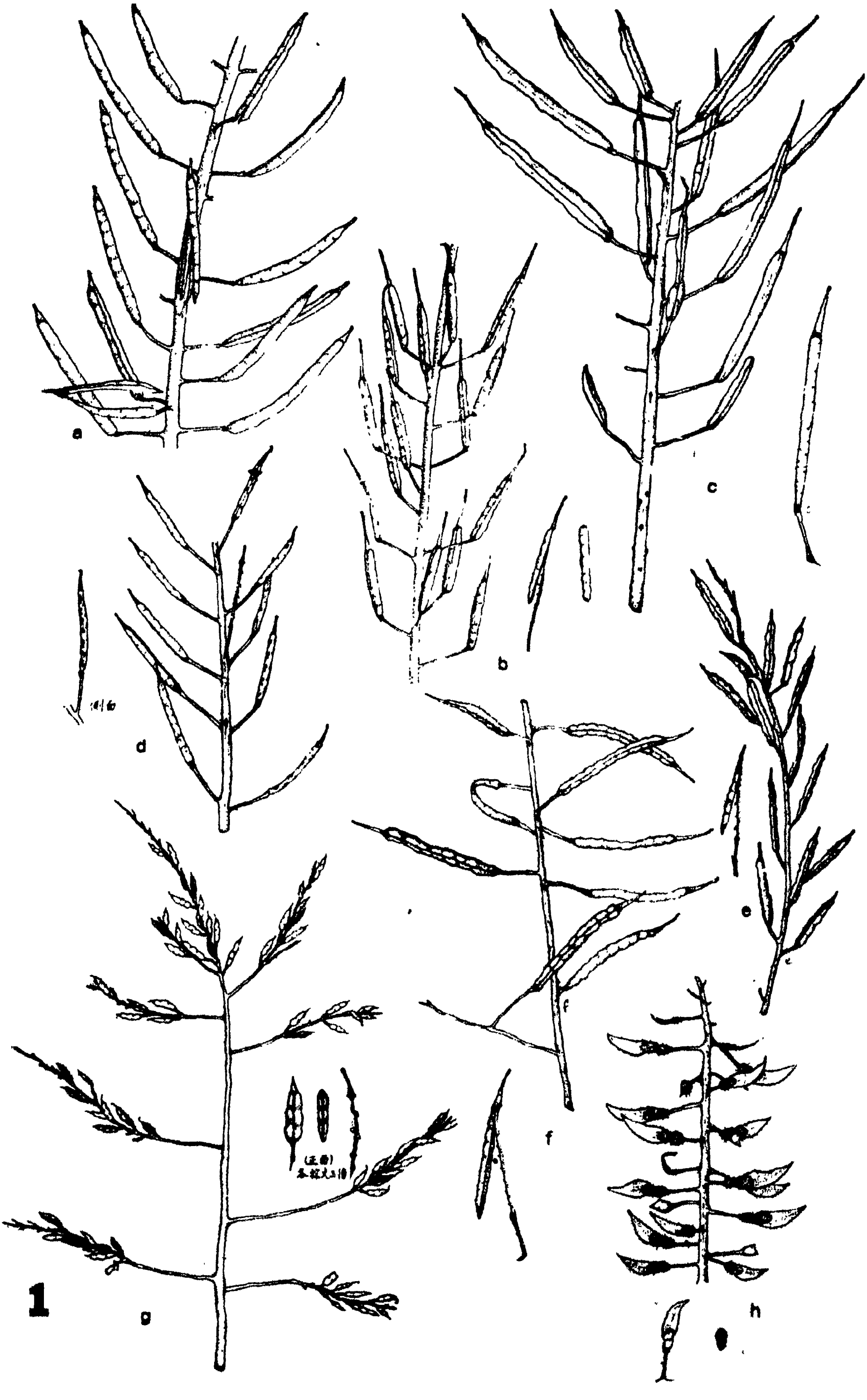
It is evident that significant differences in size of pollen grains exist among the species examined. According to the writer's previous observations (1943b) and the results shown in table 2, one can conclude that *Sinapis alba, B. juncea* var. *orthocarpa, B. napella,* and *B. napus,* should be classified as large-pollen species, and *B. nigra, B. campestris, B. carinata,* and *B. chinensis* var. *pandurata* included in the small-pollen group. The pollen length of *B. campestris* is significantly less than that of any other observed species; there are no significant differences among *B. nigra, B. chinensis* var. *pandurata*, and *B. carinata.* The pollen of *Sinapis alba* is significantly longer than that of other observed species; there are no significant differences among *B. juncea* var. *orthocarpa, B. napus,* and *B. napella.* It should be remembered that *Sinapis alba* has $n = 12$, and *B. carinata* $n = 17$. If the pollen size is closely related to the haploid chromosome number, then in this case the relation is disproved. But if, on the other hand, we exclude *Sinapis alba* and consider the pollen of *B. carinata* as intermediate, the relation will prove to be real. Generally speaking, *Sinapis alba* has a lower chromosome number but larger pollen size than other species of *Brassica.* One might expect that it would prove to be of very different genetic origin and to have remarkable morphological characters.

TABLE 2. *Mean length, mean width, and the product of length × width of pollen grains in different species of Brassica.*

Species	Length (μ)	Width (μ)	Length × width (μ²)
Sinapis alba	44.2	29.5	1304.3
B. nigra	35.0	26.1	914.1
B. campestris	32.4	23.8	772.7
B. chinensis var. *pandurata*	36.0	24.7	888.3
B. carinata	37.0	27.8	1030.9
B. juncea var. *orthocarpa*	39.5	29.8	1179.8
B. napella	40.0	28.9	1157.3
B. napus	41.2	29.1	1200.4
Least significant differences at 5% point	1.4	1.0	...

2. Hairiness of Plant. This very distinct character was used by Engler and Gilg in the division of Cruciferae into two groups. According to all available material, the 9-, 19-, and 17-chromosome species are essentially glabrous; the 8-, 10-, and 18-chromosome species are more or less sparsely setose-hairy on young leaves and stems; on the ribs and veins of mature leaves much depends upon the variety examined. Moreover, the siliques of all species are glabrous, except that that of *Sinapis alba* has long setose hairs on the whole body of the fruit. This should be considered one of the significant differences between *Sinapis alba* and all species of *Brassica* proper (fig. 1).

3. Stem Characters. The writer has observed that the stems of all available species of *Brassica* are practically cylindric, having a very smooth sur-



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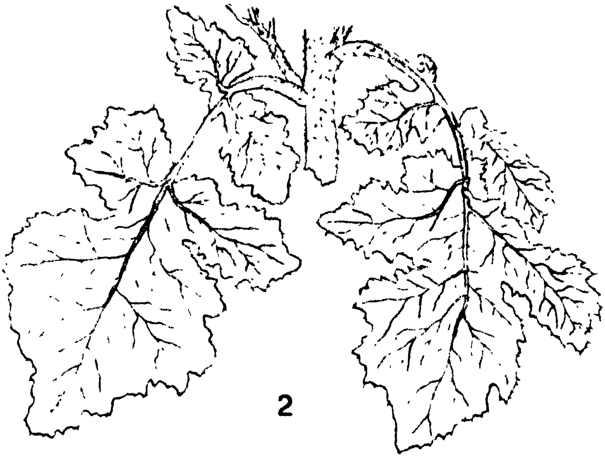
face; but that of *Sinapis alba* is very rough, and has vertical furrows or ridges evenly distributed through its whole length (fig. 2). Since this character has not been found in other species, it may be considered as characteristic of *Sinapis alba.*

The stem of kohlrabi is thickened and bulb-like (fig. 3). In other characters it is rather closely related to *B. oleracea.* Kohlrabi should be placed in the 9-chromosome group and considered as a variety of this species, as Engler and Gilg did. As to the inheritance of the "bulb," the F_1 of the cross cabbage × kohlrabi is intermediate between the two parental races. In F_2 both forms reappear, but the majority of plants form a continuous series from one extreme to the other (Malinowski 1929, Pease 1926, 1927). Pease suggested three multiple genes, two of which, B1 and B2, are major while the third, B3, is minor or modifying. The triple recessive represents the ordinary stem of cabbage or kale. When both major genes are homozygous a kohlrabi bulb is formed. In a plant containing the two major genes it is not possible to detect by eye the presence of the minor gene. In the absence of the major genes, the minor converts "stalk" into "semi-bulb." On this hypothesis the ratio of the three classes, bulb : semi-bulb : stalk, should be 4 : 59 : 1; the actual figures obtained by Pease agree with this expectation.



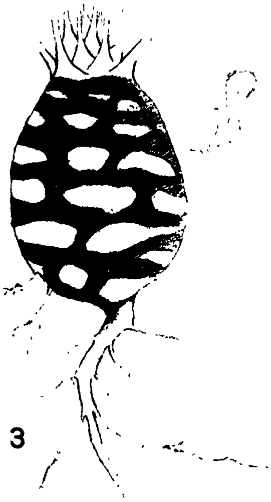


FIG. 2. Stem and leaves of *Sinapis alba.* FIG. 3. Thickened bulb-like stem of *B. oleracea* var. *gongylodes.*

The stem of *B. juncea* var. *tumida* is characterized by its enlarged rudi-

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Explanation of figure 1

Siliques of various species of *Brassica* and of *Sinapis alba.* a, *B. oleracea* var. *acephala;* b, *B. campestris* var. *oleifera;* c, *B. chinensis* var. *pandurata;* d, *B. juncea* var. *gracilis;* e, *B. carinata;* f, *B. napus* var. *oleifera;* g, *B. nigra;* h, *Sinapis alba.*

mentary petioles and the shortened internodes of the lower part of the stem, a character which has not been found in other species (fig. 4). Because the plant differs in no other major character from varieties of *B. juncea,* it should be regarded as a variety of this species.

B. juncea var. *linearifolia* is characterized by a weak stem which is easily lodged under heavily manured or stormy conditions. In cross section the stem is rather irregular, not circular; it probably contains little lignified tissue. The writer has unpublished data to show that this weakness may be controlled by a single recessive gene. Other characters of the plant, except leaf-shape, are as in other varieties of *B. juncea.*

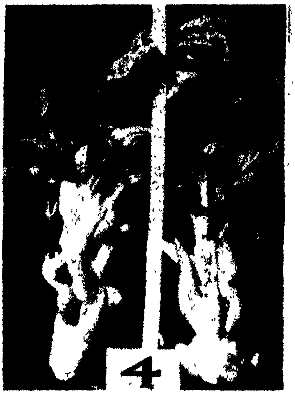


FIG. 4. Swollen and enlarged rudimentary petioles and nodes of *B. juncea* var. *tsatsai.*

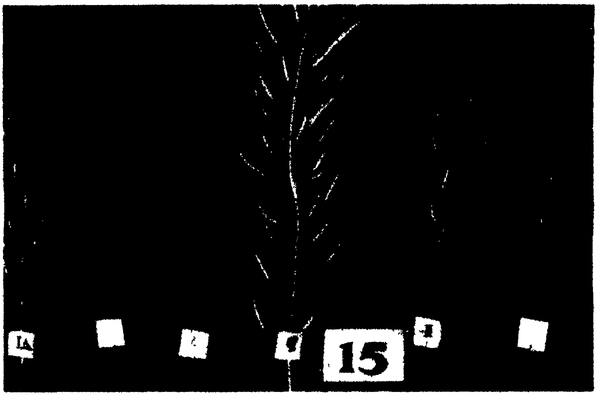


FIG. 15. Siliques of some species of *Brassica.* I, *B. juncea* var. *orthocarpa;* II, *B. juncea* var. *gracilis;* III, *B. chinensis* var. *pandurata;* IV, *B. campestris* var. *rapifera* (snowball); V, *B. campestris* var. *rapifera* (extra early purple top); VI, *B. chinensis* var. *albiflora.*

4. Root Characters. In certain species of *Brassica,* some roots are enlarged while others are not. Type of root has long been recognized as an important taxonomic character. Enlargement is only found in the 10-, 18-, and 19-chromosome species. This fact might lead one to postulate that the character has a single genetic origin. *B. rapa* may be considered as the original species of *Brassica* with enlarged storage root and rutabaga as derived from the combination of *B. oleracea* × *B. rapa* through chromosome doubling. Similarly, storage-rooted mustard (*B. juncea* var. *megarrhiza*) may be derived from the combination of *B. nigra* × *B. rapa.* However, the hypothesis is not supported by actual data. Kajanus' (1917) genetic studies and Morinaga's cytologic investigations should be considered as good examples for further study.

Color variation of the root of the tuberous-rooted species and varieties is very wide. The main coloring of the interior parts (the "flesh color"), both of turnip (*B. rapa*) and swede or rutabaga (*B. napus* var. *napobrassica*), is either white or yellow. The yellow color is not due to a pigment in solution, but is borne in plastids. When yellow- and white-rooted plants are crossed, irrespective of which is the mother plant, the F_1 hybrids are all white-fleshed. If these are selfed the F_2 generation segregates 3 white to 1 yellow. The color inheritance in swedes is slightly more complex, the genes being duplicated. Hallqvist (1915), Kajanus (1913), and Davey (1931), working independently, have found certain white-fleshed varieties to contain both genes breeding true for the white color. When a white-fleshed plant of this nature is crossed with a yellow-fleshed swede, the F_1 is all white-fleshed. If these F_1 plants are selfed, the F_2 generation segregates 15 white to 1 yellow. In swede × turnip crosses, Kajanus found (1917) that the gene for white in turnip masks the yellow of the swede, while the white swede genes are dominant over the yellow of the turnip. In other words, the hereditary factors governing flesh color in both species are very similar, though more complex in the swede.

Swede strains are commonly grouped according to skin color as "purple top," "bronze top," and "green top." Kajanus (1912) suggested two genes governing them: P_1 giving red-green and dominant to green, and P_2 giving red and dominant to both red-green and green. Later (1913), however, he discarded P_1 because of the irregularity with which color appeared, and considered red-green and green to be fluctuating characters. Davey (1932), after re-examining the anthocyanin color inheritance in swedes, redefined Kajanus factor P_2 as N_1, which produced self-red or self-purple on the surfaces between leaf-scars of the "neck," and, with less certainty, strong vinous mauve on the "top." Another gene, N_2, was found, similar in action to but not identical with N_1. Complete absence of linkage was found between factors N_1 and N_2, and between these and the genes M_1 and M_2 which govern flesh color. Kajanus has shown that the genes governing flesh color in turnip and swede are probably the same. These facts and the frequent occurrence of duplicate factors in swedes may be considered as genetic evidence in favor of Morinaga's cytological viewpoint.

As to the shape of storage organs, Kajanus (1913) assumes that two multiple factors L_1 and L_2 are responsible for the length of the turnip "roots." The root-shapes produced by the different combinations of these genes are as follows:

Combination of genes	Number of genes	Shape of root
$L_1L_1\ L_2L_2$	4	long
$L_1L_1\ L_2l_2$	3	rather long
$L_1l_1\ L_2L_2$	3	rather long
$L_1L_1\ l_2l_2$	2	elongated
$l_1l_1\ L_2L_2$	2	elongated
$L_1l_1\ L_2l_2$	2	elongated
$L_1l_1\ l_2l_2$	1	rather short
$l_1l_1\ L_2l_2$	1	rather short
$l_1l_1\ l_2l_2$	0	short

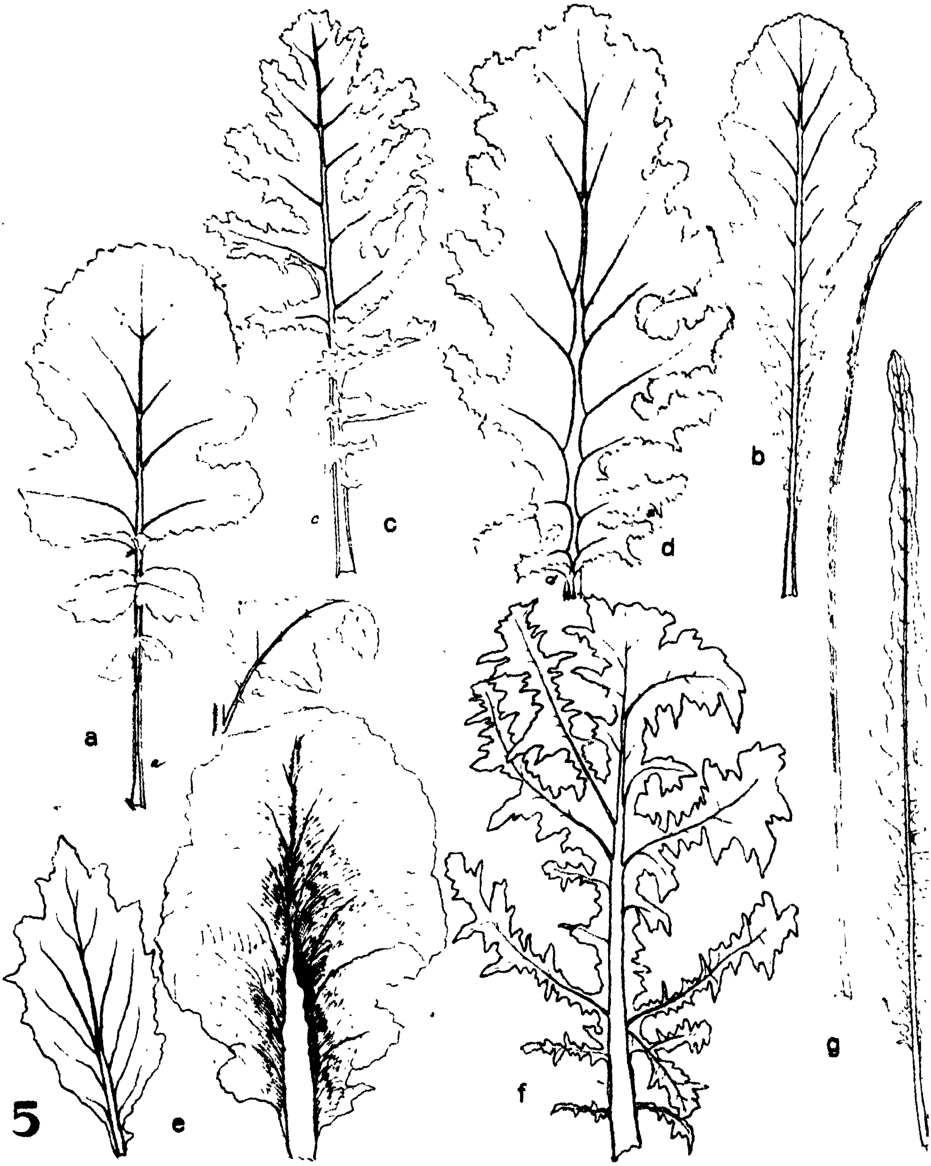


FIG. 5. Leaf-shapes of different varieties of *B. juncea*. a, var. *gracilis*; b, var. *oblanceolata*; c, var. *megarrhiza*; d, var. *tsatsai*; e, var. *rugosa*; f, var. *multisecta*; g, var. *linearifolia*.

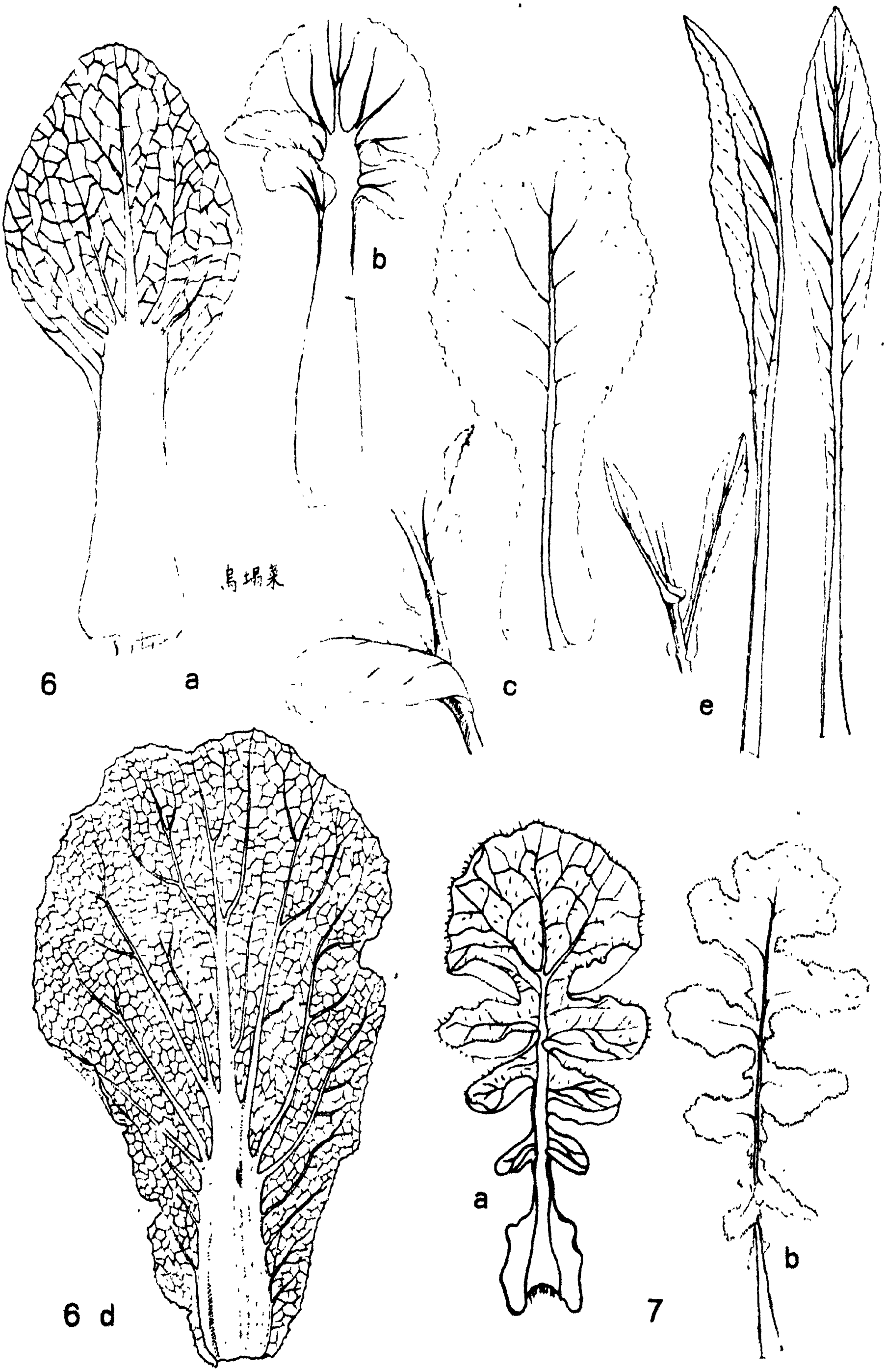
5. Shape of Foliar Organs. The leaf shape of *Brassica* is quite variable even within a single species. For example, *B. juncea* var. *gracilis* has long-petioled radical leaves, the blades obovate to oblong-ovate, with small lobes gradually diminished toward the base; *B. juncea* var. *oblanceolata* has oblanceolate radical leaves and weak grooved petioles, the blades irregularly incised, sharply serrate toward the base and not lobed; *B. juncea* var. *rugosa* has large and quick-growing radical leaves 30 cm. or sometimes 60–90 cm. long, obovate or oval, and stout and broad petioles, the blades extending to their base; *B. juncea* var. *crispifolia* has large crisped, curled, and fringed leaves; *B. juncea* var. *multisecta* has leaves multifid into linear or even filiform lobes; *B. juncea* var. *linearifolia* has all leaves linear, stem-leaves bladeless, and radical leaves with blades very narrow above but irregularly notched below. The writer has unpublished data to show that certain leaf-forms of *B. juncea* are inherited as simple Mendelian characters. It would be unwise to use these leaf-forms as the basis for the distinction of species. (See figure 5.)

In the 10-chromosome species also diverse leaf-forms are found. For example, *B. chinensis* var. *communis* has glabrous, rounded, undivided, entire radical leaves, tapering into long but unwinged, whitened petioles, and auriculate-clasping stem-leaves; *B. chinensis* var. *rosularis* has the radical leaf-blades broad-ovate or suborbicular, entire, distinctly marked with a number of veins, with thickened, broad, and greenish-white petioles, these scarcely bearing leaf-fragments; *B. chinensis* var. *pandurata* has the radical leaves pandurate or fiddle-shaped to oblong-obovate, tapering to narrow slender petioles which are margined and usually bear leaf-fragments or ear-like lobes below, unable to support the blades in an erect position; leaf-blades and midribs are more or less sparsely covered with setose hairs; *B. chinensis* var. *pekinensis* has radical leaves with characteristic broad-winged petioles, and its heart-leaves are crinkled, tending to form a head under suitable environmental conditions; there are a few setose hairs on the ribs beneath; *B. chinensis* var. *angustifolia* has stem-leaves non-clasping, long and narrow, petiolate or with a narrow base; its radical leaves are long and narrow, sometimes curly. (See figure 6.)

Radical leaves of *B. rapa* and *B. campestris* are long-obovate to oblong-ovate, lyrate-pinnatifid, petiolate, densely covered above and below with setose hairs (fig. 7).

Leaf-forms of different varieties of *B. oleracea* are also variable. They are all practically glabrous. Radical leaves of vars. *acephala* and *gongyloides* are relatively small, oblong-ovate, petiolate, with leaf-fragments on the lower part; radical leaves of var. *capitata* are sessile, large, mostly thick, broad-orbicular.

The investigation of the genetics of leaf characters of the races of *B. oleracea* as well as other races has proved difficult. Not only are these characters elusive of exact definition but also the type of leaf changes with age of the plant. Pease (1926) gives much evidence for the existence of two genes: *P*, which causes the leaf to be petiolate, and *E*, which causes it to be entire as


b
烏塌菜
6
a
c
e
6 d
a
7
b

against lyrate. He suggests for cabbage the formula *ppEE,* and for kale and kohlrabi *PPee.* Brussels sprouts contain *PPEE.* The rare type of foliage "sessile lyrate" is presumably *ppee.*

The leaves of kohlrabi are narrower than those of cabbage. Pease reports for crosses of these two that when the F_2 plants with leaves about as narrow as the parent kohlrabi are picked out, they are found to form a quarter of the total number. He concludes on the basis of F_2 and F_3 data that one principal gene, *W*, is involved in this character difference.

Pease investigated a monstrosity of the leaf in which outgrowths developed from the ribs, running at right angles to the surface of the leaf. This anomalous growth is usually of a leafy nature, but may become stalky and even bear flowers and set seeds. This character, called "asparagodes," behaves as a simple dominant.

Another leaf character is worth noting, the curly foliage of curly kale, which seems to be determined by several multiple factors (Malinowski 1929, Pease 1926). The leaves of kale are well curled, those of cabbage flat or at most a little wavy. Hybrids are intermediate. F_2 segregation yields a continuous though asymmetric variation between the parental types.

In ordinary cabbage, the leaves of the terminal shoot are closely folded, forming the familiar dense head or heart. In Brussels sprouts, the same sort of deformity occurs, not in the terminal shoot but in the laterals. The two forms of hearting are determined by independent Mendelian factors and in the commonly cultivated types both forms do not appear on the same plant. The F_1 from cabbage × kale, × kohlrabi, or × any non-hearting *B. oleracea* other than Brussels sprouts is a plant with slight indications of hearting. The leaves of the rosette are curved inwards, but do not form a closed head. In the F_2 both parental forms appear, but the majority of the plants form a continuous range from one extreme to the other (Malinowski 1929, Kristofferson 1924, Pease 1926). Malinowski suggested multiple genes responsible for the hearts, determining the difference in degree of folding of leaves. His experiments indicate a possibility of 3 multiple genes. Pease gave evidence for a 2-gene system.

Kristofferson, who has made crosses between cabbage and Brussels sprouts, is inclined to believe that the cause of the development of heads in the leaf axils is not of a simple monohybrid type. The F_1 resembles Brussels sprouts, having well developed "buttons" in the leaf axils. At the top of the stem a large, rather compact head is formed. The development of buttons in the axils varies continuously in the F_2. In some plants these buttons are as

Explanation of figures 6 and 7

FIG. 6. Leaf-shapes of different varieties of *B. chinensis.* a, var. *rosularis;* b, var. *albiflora;* c, var. *pandurata;* d, var. *pekinensis;* e, var. *angustifolia.* FIG. 7. Leaf-shapes of (a) *B. campestris* var. *oleifera;* and (b) *B. campestris* var. *rapifera.*

well developed as in Brussels sprouts; in others they have the ordinary loose structure of kale.

Stem-leaves of *B. napus* are oblong-lanceolate, sometimes toothed and notched; the radical leaves are oblong-ovate (fig. 9).

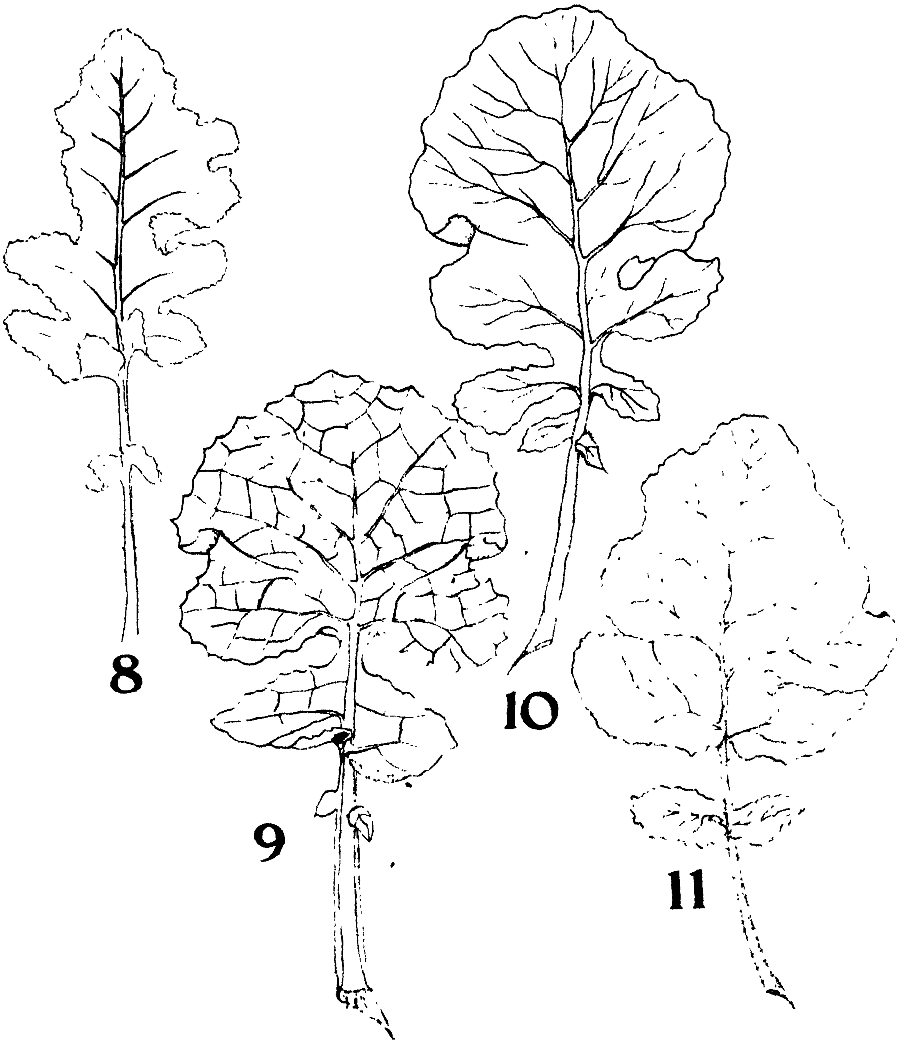


FIG. 8. Leaf-shapes of *B. oleracea* var. *gonglyodes*. FIG. 9. Leaf-shape of *B. napus*. FIG. 10. Leaf-shape of *B. carinata*. FIG. 11. Leaf-shape of *B. nigra*.

The basal leaves of *B. carinata* are shining, with large oval lobes 3–5 inches long, shallowly sinuate-dentate, with small lobes at the base and sometimes fragments on the long petiole; these leaves pass gradually into narrow upper cauline petiolate or narrow-based variously dentate floral leaves or bracts (fig. 10).

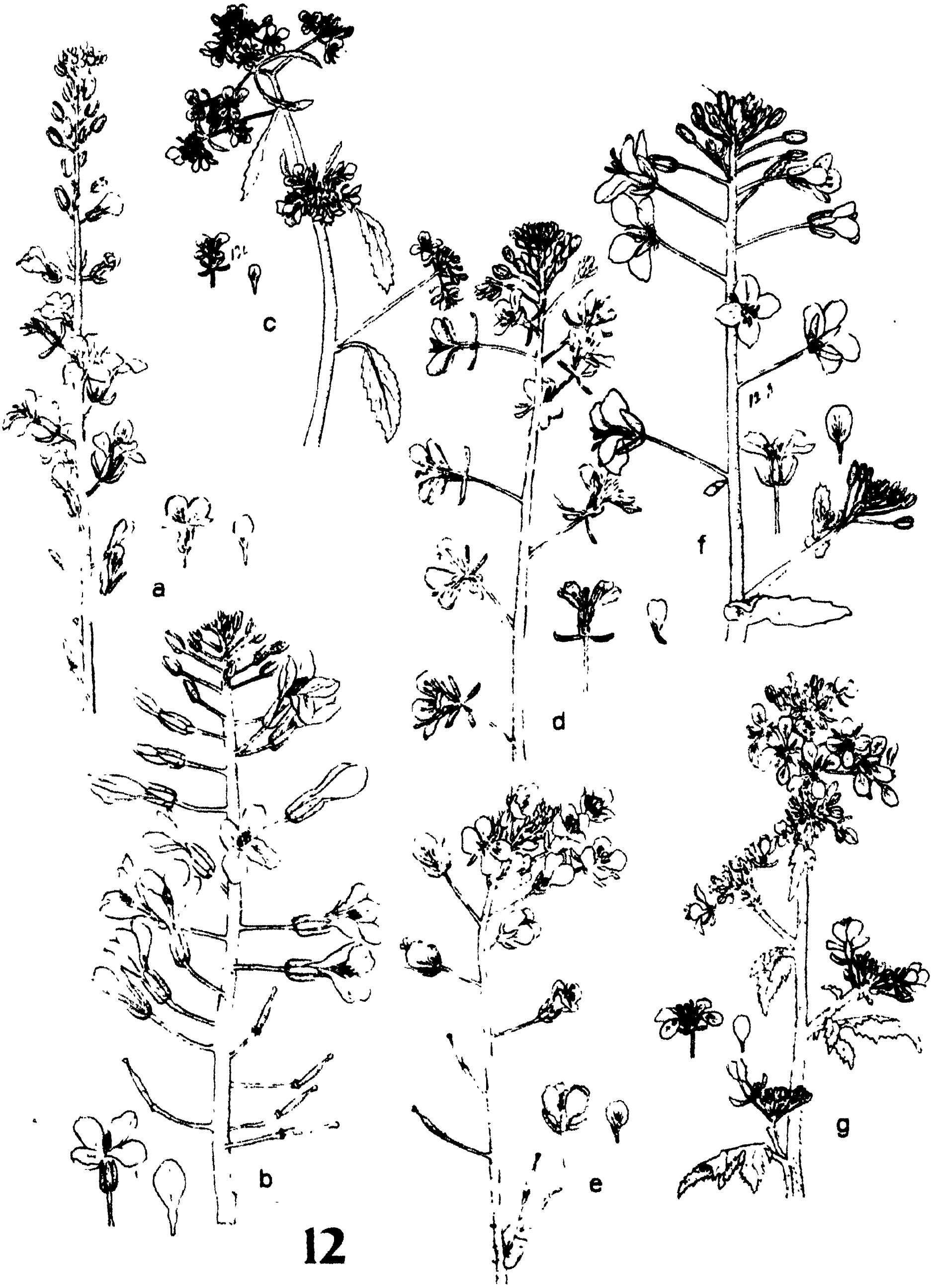


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FIG. 12. Types of inflorescence of different species of *Brassica* and of *Sinapis alba*. a, *B. carinata*; b, *B. oleracea* var. *acephala*; c, *B. nigra*; d, *B. juncea* var. *gracilis*; e, *B. campestris* var. *oleifera*; f, *B. napus* var. *oleifera*; g, *Sinapis alba*.

Leaves of *B. nigra* are densely covered with hispid hairs, the radical not greatly developed, pinnatifid or lobed, the terminal lobe very large, the margins dentate or notched, long-petiolate as are the stem-leaves (fig. 11).

The leaves of *Sinapis alba* are oval, ovate, or obovate, divided deeply—even to the midrib—into 1–3 pairs of notched or angled lobes; the stem-leaves are long-petiolate, sparsely covered with setose hairs.

6. Glaucescence and Color of Plant. Bailey divided all species of *Brassica* into two main groups based upon glaucescence. All 9-chromosome and 19-chromosome species are glaucous-blue or blue-green, sometimes glaucous-red in horticultural varieties. It has been noted in the 10-chromosome species that glaucescence is found in *B. campestris* and *B. chinensis* var. *rosularis,* the others being essentially not glaucous. In Bailey's key to the species, *B. napiformis* was placed in the 9- and 19-chromosome section because of its glaucescence. However, by examination of other important characters such as those of flower and fruit, it should undoubtedly be placed in the 18-chromosome group.

According to the writer's observation, *B. carinata* is practically not glaucous but rather prominently glossy or shining.

As to the anthocyanin pigmentation of the foliage, red and purple have often been found in different species and varieties. For example, *B. chinensis* var. *purpurea* may be considered as the typical purple variety in the 10-chromosome group. The purple pigment is distributed practically throughout the whole plant except the petals. Purple mustard also has been found in Tsun-Yee, Kweichow, China; it belongs to *B. juncea.* The distribution of purple pigment can be identified as of three types. In the first the pigment is confined to the leaf-blade, while the stem and petiole or midrib are essentially green; in the second type purple is distributed practically throughout the plant except the petals; in the third purple is confined to the leaf-venation, and is not easy to detect without close observation. The mode of inheritance of color remains obscure. Genic analysis of the anthocyanin pigment formation of both 10- and 18-chromosome species has just been undertaken by the writer and Mr. C. S. Chu in the College of Agriculture of the National University of Chekiang.

Color variation in the foliage of 9-chromosome species is also wide. Results of genetic studies on color inheritance of the cabbage races are summarized in the following paragraphs.

Kristofferson (1924) reported extensive investigations on light red color of the midvein in cabbage and in Brussels sprouts. Crosses were made with broccoli, which was green in these parts. In the F_1 the midvein was light red; in F_2 the ratio was 3 light red : 1 green midvein. He designated the gene for light red as *B;* broccoli has *b.* A cross between light-red-midveined cabbage and a similar type in Brussels sprouts produced only light red in F_1 and F_2, showing that the two factors were the same. This light red type was later referred to by Kwan (1934) as "sun-red." When kale, which has a green midvein, was crossed with this light red type, the F_1 had a dark red-violet midvein. The F_2 plants segregated into dark red-violet, light red, and green in a ratio approximating 9:3:4. This would indicate complementary genes. He assumed a factor *A* in kale which interacted with a factor *C* in cabbage or Brussels sprouts to produce this dark red-violet vein color; kale is *Ac* and cabbage or Brussels sprouts is *aC*. In F_2 there was a deficiency of the light red type carrying *B*, and a proportional excess of the green *b* type. This deviation, he suggested, might be due to linkage of *B* with either *A* or *C*. Since the crosses of broccoli with cabbage and with Brussels sprouts did not give dark red-violet midveins, broccoli must be *a*.

In further studies, Kristofferson (1924) found complete dominance of dark red leaf in the cross of green-leaved light-red-midveined cabbage with a dark-red-leaved type. In the F_2 there were approximately 3 dark-red-leaved plants to 1 green. This was also true in crosses of dark-red-leaved cabbage by kale, by Brussels sprouts, and by broccoli. He suggested the gene *D* for the dark coloration of red cabbage. But in the cross of kale with green-leaved light-red-veined cabbage or with Brussels sprouts, the leaf-color of the F_1 was dark red-violet. The F_2 ratio could not be explained by a simple hypothesis, since the variation was continuous. In the cross between red cabbage and tall kale, the F_2 ratio of intermediate and green to dark red was approximately 3:1. In the light red cabbage, he assumed that there was a gene *E* for extension of dark color when *A* and *C* were both present. From these results he formulated the most probable genetic constitution of the various types as follows:

Cabbage	dd	aa	BB	CC	EE
Red cabbage	DD	AA	bb	cc	ee
Brussels sprouts	dd	aa	BB	CC	EE
Kale	dd	AA	bb	cc	ee
Broccoli	dd	aa	bb	CC	EE

Pease (1927) assumed that in the purple kohlrabi two genes for pigment were present. His hypothesis is supported by the cross of purple kohlrabi × green savoy cabbage. Purple F_1 plants were obtained, giving a ratio of 9:7 in F_2. In crosses of purple F_1 plants with green cabbage the green behaves as a simple recessive to purple. Green cabbage, therefore, probably contains one of the complementary color genes present in purple kohlrabi.

About 1926, Dr. C. H. Myers of Cornell University found among the progeny of a selfed plant of the variety "Danish round red" a new color type which he named "magenta." Magruder (1930) obtained purple plants in the F_1 of a cross between sun-red and magenta. The F_2 contained 9 purple: 3 magenta: 3 sun-red: 1 green. The assumption of two genes explains these results. The gene *M* is designated as responsible for the production of magenta and *S* for the production of sun-red. The purple type is *MS*, the green *ms*.

Kwan (1934) stated that a cross of deep purple × sun-red cabbage gave an F_2 ratio of 15 purple : 1 sun-red. The F_3 and intercross tests show that the assumption of two duplicate genes, R_1 and R_2, for purple will explain the results. The genes are shown to be cumulative in effect. From the cross deep purple × green a ratio of 9 purple : 3 sun-red : 4 green resulted. The F_3 fits the assumption that two genes are involved: *G*, a basic factor for pigment, which with *A* gives purple and with *h* gives sun-red.

7. Branching Habit. It has been noted by Bailey that *B. rapa* does not branch near the base, whereas *B. juncea* and *B. chinensis* do. According to the writer's observation, the variation in branching habit is very wide. *B. nigra* may be noted as an extremely high-branched species. The lowest branches of the main stem are not necessarily all low in *B. juncea* and *B. chinensis*. *B. juncea* var. *oblanceolata*, however, is an extremely low-branched variety of that species. It develops as many as 7–10 branches within 10 cm. of the ground. Certain other forms, such as *B. juncea* vars. *gracilis* and *orthocarpa*, practically never send out branches up to 90 cm. above the ground. Some varieties of *B. chinensis* branch very low and some rather high; but the highest-branching varieties never reach the height of some varieties of *B. juncea*.

B. oleracea, *B. napus*, and *B. carinata*, as far as the available material shows, all branch low.

In 1941, random samples of 50 plants in each of *B. chinensis* var. *pandurata* and *B. juncea* vars. *gracilis* and *orthocarpa* were measured for their plant height and the height of the lowest branching node. The results are shown in table 3. Significant differences exist among varieties in both plant height and height of the lowest branch.

TABLE 3. *Mean plant height and the lowest branching height in 3 varieties of yu-tsai (Chinese rape).*

Variety	Mean plant height	Mean branching height
B. chinensis var. *pandurata*	104.9	15.9
B. juncea var. *gracilis*	168.6	53.4
B. juncea var. *orthocarpa*	195.4	96.1
Significant difference at 5% point	10.8	9.1

Though the mode of inheritance of plant height and height of branching of different species is still unknown, it is certain that the importance of these characters in taxonomic studies should not be overlooked.

8. Type of Inflorescence at Anthesis. Bailey recognized this character as important in the separation of *B. oleracea* from other species. He described the inflorescence of *B. oleracea* as elongate and open at anthesis, 10–25 cm. long, while that of *B. napus* was short, the flowers clustered at the top and the blooming part usually 6 cm. or less in length. According to the writer's observation, this distinction is well marked. In general, the inflorescence of all varieties of *B. chinensis*, *B. juncea*, and *B. napus* is rather short at anthesis, the unopened flower-buds corymbosely clustered at the top, never elongate, and the part bearing opened flowers also short. The inflorescence of *B. carinata* is extremely elongate, i.e., opened flowers and unopened buds on the rachis are very widely separated. Since this is typical of *B. oleracea*, these two should be placed in the same group as far as this character is concerned.

TABLE 4. *Mean length of the blooming part of the inflorescence of 21 varieties of Brassica (1941).*

Species & variety	Common name	Mean length of blooming part
B. oleracea var. *capitata*	Common cabbage	11.9
B. oleracea var. *acephala*	Yellow-flowered kale	8.3
B. juncea var. *tumida*	Ling-chiao-tsai	7.0
B. chinensis var. *angustifolia*	Kweilin hwa-tsai (1)	6.7
B. juncea var. *rugosa*	Nanfeng chieh-tsai	6.2
B. juncea var. *gracilis*	Meitan da-yu-tsai	5.9
B. chinensis var. *pandurata*	Meitan siao-yu-tsai	5.6
B. chinensis var. *angustifolia*	Kweilin hwa-tsai (2)	4.8
B. napus var. *napobrassica*	Rutabaga	4.7
B. chinensis var. *communis*	Kasin green-petioled	3.5
B. chinensis var. *pekinensis*	Meitan hwang-ya-tsai (1)	3.3
B. chinensis var. *pandurata*	Shian-tan yu-tsai	3.3
B. oleracea var. *alboglabra*	White-flowered kale	3.2
B. chinensis var. *pekinensis*	Meitan hwang-ya-tsai (2)	3.1
B. oleracea var. *gongyloides*	Red kohlrabi	2.7
B. chinensis var. *communis*	Kiangmen pe-tsai	2.6
B. chinensis var. *albiflora*	Pe-hwa-piao-er-tsai	2.2
B. chinensis var. *communis*	Ishan pe-tsai	2.0
B. juncea var. *oblanceolata*	Shealiehung chieh-tsai	1.9
B. juncea var. *megarrhiza*	Pe-pa-yeh da-tou-tsai	1.7
B. chinensis var. *communis*	Kwangsi long-petioled	1.7
Significant difference at 5% point	. .	1.15

It should be noted that environmental conditions play a part in fluctuation of this character. Measurements of the length of the blooming part made on different days will vary greatly. When the air temperature is high and the relative humidity is low, the flowering process tends to be rapid, hastening the early fall of the petals; measurements taken under such conditions will be short. But if the air temperature is low and the humidity is high, flowering tends to be delayed and the petals persist longer on the flower. Measurements made at such times will be longer.

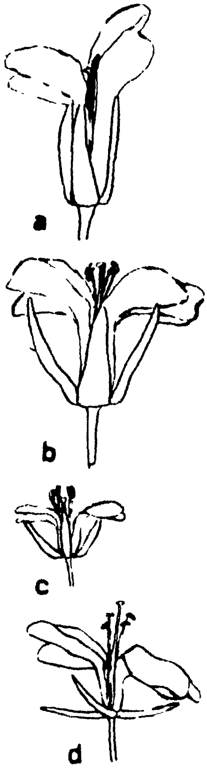
In the spring of 1941, random samples of 10 measurements on each of 21 specimens were made on successive days. Comparisons of the mean length of the blooming part for all varieties are shown in table 4. Analysis of variance between and within varietal classes for the 210 measurements was calculated. It is clear that variation in length of the blooming part among varieties and species is highly significant.

From table 4 it is evident that according to the type of inflorescence, *Brassica* may generally be divided into two groups, as pointed out by Bailey. One is the long loose type which includes certain varieties of *B. oleracea* and *B. carinata;* the other is the short compact type which includes some varieties of *B. oleracea* and all varieties of *B. juncea*, *B. chinensis*, and *B. napus*. Since variation of the two types is essentially continuous, one can hardly draw an accurate borderline between the groups. As far as present data are concerned, one may consider mean lengths of inflorescence above 8 cm. and below 7 cm. as the long loose and short compact types respectively. This is an arbitrary standard and may need modification.

9. Type of Sepals at Anthesis. Bailey recognized this character as important in the classification of species. In his key to the species, he distinguished two groups: under A are species whose sepals are mostly firmly erect and not spreading, such as *B. oleracea*, *B. napus*, and *B. napiformis;* under AA are those whose sepals are separate or spreading, such as *B. campestris*, *B. rapa*, *B. juncea*, *B. pekinensis*, *B. chinensis*, *B. nigra*, and *B.* (*Sinapis*) *alba*.

According to the writer's observation, three types of sepals may be found in *Brassica*. First is the firmly erect type (fig. 13, a) which includes most varieties of *B. oleracea*, such as common cabbage and kohlrabi; second is the separate type, with an angle formed between the sepals and the central axis of the flower of approximately 30–45°, which includes *B. carinata*, *B. napus*, *B. napobrassica*, *B. napiformis*, *B. campestris*, and most varieties of *B. chinensis;* third is the wide-spreading type, with sepals at anthesis perpendicular to the central axis (fig. 13, c), which includes *B. nigra*, *Sinapis alba*, and almost all varieties of *B. juncea*. Observation of these types must be made at a time when the flowers are fully open.

10. Size and Shape of Petals. Size and shape of petals should be considered as important taxonomic characters of *Brassica*. Bailey divided the species into two groups by length of petals. One is the long-petal group, the petals ranging from 15 to 25 mm. long, which includes all varieties of *B. oleracea*. The other is the short-petal group, the petals being 15 mm. or less in length, which includes *B. napus* and *B. napobrassica;* but varieties of *B. chinensis*, *B. campestris*, and *B. juncea* are said to have petals only from 10 to 12 mm. long. Data have been obtained by the writer and his coworkers to show variation in length and width of the petals. Ten random measurements of the length and width in each of 22 specimens and 20 measurements in each of 8 specimens were made in 1941 and 1943 respectively. In 1944, 10 random measurements in each of 13 specimens were made. Comparisons of variety and species means are shown in tables 5, 6, and 7.



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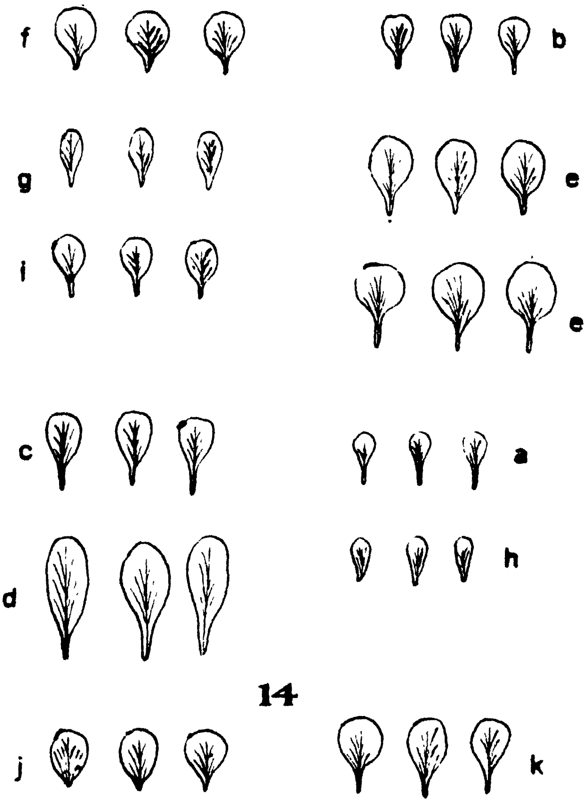

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FIG. 13. Types of sepals of some species of *Brassica* and of *Sinapis alba*. a, *B. oleracea* var. *gongylodes*; b, *B. napus* var. *napobrassica*; c, *B. juncea* var. *megarrhiza*; d, *B. juncea* var. *rugosa*. FIG. 14. Shape of petals of species of *Brassica* and of *Sinapis alba*. a, *B. nigra*; b, *B. juncea* var. *gracilis*; c, *B. carinata*; d, *B. oleracea* var. *acephala*; e, *B. napus* var. *oleifera*; f, *B. chinensis* var. *pandurata*; g, *B. campestris* var. *oleifera*; h, *B. campestris* var. *rapifera*; i, *Sinapis alba*.

Evidently great variation in petal size exists among different varieties and species of *Brassica*. Bailey's observation may generally be considered correct, but his classification into large-flowered and small-flowered groups is not entirely satisfactory. Perhaps *Brassica* may be fairly accurately divided into four groups by petal length. First is the small-flower group, with petal-length from 7 to 9 mm.; *B. nigra* and a few varieties of *B. rapa* are representative. Second is the medium-small-flower group, with petal-length from

TABLE 5. *Mean length and width of petals of different varieties and species of Brassica (1941).*

Common name	Length (mm.)	Width (mm.)	Length / Width
Yellow-flowered kale	23.9	11.9	2.0
Common cabbage	23.6	10.2	2.3
White-flowered kale	21.3		
Red kohlrabi	20.8	8.5	2.4
Meitan siao-yu-tsai	13.2	9.8	1.3
Meitan da-yu-tsai	12.5	6.3	2.0
Kiangmen pe-tsai	12.4		
Kwangsi long-petioled	12.3		
Kweilin hwa-tsai (1)	12.2	7.7	1.6
Nanfeng chieh-tsai	11.8	7.0	1.7
Tson-tsai	11.7	5.0	2.3
Da-tou-tsai	11.6	5.4	2.1
Hwang-ya-tsai (1)	11.6		
Shiantan yu-tsai	11.6	6.9	1.7
Ishan pe-tsai	11.6		
Kweilin hwa-tsai (2)	11.4	7.7	1.5
Rutabaga	11.2	6.6	1.7
Ling-chiao-tsai	11.1	5.8	1.9
Pe-hwa piao-er-tsai	11.1	8.1	1.4
Hwang-ya-tsai (2)	10.7	6.9	1.5
Kasin green-petioled	10.2	5.8	1.7
Shealiehung chieh-tsai	9.8	4.6	2.1
Snowball turnip	9.0	4.5	2.0
Significant difference at 5% point	0.92	0.64	

9 to 13 mm.; this includes all varieties of the 10- and 18-chromosome species. Third is the medium-large-flower group, with petal-length from 13 to 17 mm.; this includes all varieties of the 17- and 19-chromosome species. Fourth is the large-flower group, with petal-length from 18 to 25 mm.; *B. oleracea* is representative.

It is evident from tables 5, 6, and 7 that significant differences among different varieties within each of the four groups may also be found. For instance, in table 5, the mean pétal-length of the yellow-flowered kale is sta-

TABLE 6. *Mean length and width of petals of different species of Brassica (1943).*

Species	Length (mm.)	Width (mm.)	Length / Width
B. nigra (English source)	7.5	3.3	2.3
Sinapis alba (English source)	11.2	6.5	1.7
B. chinensis var. *pandurata*	13.0	9.0	1.4
B. campestris (English source)	11.1	6.3	1.8
B. carinata (English source)	16.0	7.7	2.1
B. juncea var. *orthocarpa*	12.4	6.4	1.9
B. napus (English source)	14.9	8.4	1.8
B. napella (Japanese source)	15.3	9.7	1.6
Significant difference at 5% point	0.46	0.34	

tistically greater than that of white-flowered kale or red kohlrabi. Meitan siao-yu-tsai may be considered as having the longest and snowball the shortest petals in the medium-small-flower group, and significant differences may be found among these varieties. From table 6 it may be seen that the petals of *B. chinensis* var. *pandurata* are significantly longer than those of *B. campestris*, and those of *B. carinata* are longer than those of *B. napus* or *B. napella*. In table 7, one finds that the petal-length difference between *B. chinensis* var. *pandurata* and *B. campestris* is also significant, but that between *B. carinata* and *B. napus* or *B. napella* is not significant.

There is a fairly close positive correlation between length and width of petals except in Meitan siao-yu-tsai and pe-hwa piao-er-tsai, whose petals are very wide. In this connection, one may direct attention to the shape of the petals. The length-width ratio would be a factor in determining the shape; this will lead to the differentiation of the narrow-petaled and broad-petaled forms of *Brassica*. Another factor in petal-shape is the length of the claw. The writer has observed that the petals of some species are very long-clawed, and those of others very short-clawed (fig. 14). Bailey noted in his key to the *oleracea-napus* group that their petals are long-tapering to narrow bases, while in the *campestris-juncea* group they are said to be less prominently tapering. It can be seen from figure 17 that *B. chinensis* var. *pandurata* may be considered as a typical short-clawed variety and *B. rapa* (extra early purple top) has no claw at all; others, such as *B. nigra*, *B. juncea*, *B. oleracea*, *B. napus*, and *B. carinata* are all long-clawed; *Sinapis alba* is also long-clawed but the petals are rather abruptly constricted between limb and claw, not gradually tapering toward the base.

TABLE 7. *Mean length and width of petals of different species of Brassica (1944).*

Species	Length (mm.)	Width (mm.)	$\frac{\text{Length}}{\text{Width}}$
B. nigra	8.9	3.6	2.5
B. rapa (extra early purple top)	7.6	3.2	2.4
Sinapis alba	10.5	5.8	1.8
B. campestris	9.7	4.8	2.0
B. chinensis var. *pandurata*	11.5	8.2	1.4
B. juncea var. *gracilis*	10.7	6.0	1.8
B. carinata	13.7	6.8	2.0
B. napus	14.0	7.6	1.8
B. napella	13.4	8.7	1.5
B. oleracea var. *acephala*	21.7	7.8	2.8
(*B. campestris* × *B. chinensis* var. *pandurata*) F_1	11.6	6.9	1.7
(*B. napus* × *B. campestris*) F_1	12.4	7.7	1.6
(*B. napus* × *B. campestris*) F_1–21	10.9	4.4	2.5
Significant difference at 5% point	0.70	0.49	0.16

The mode of inheritance of these differences in size and shape of petals of *Brassica* seems not to have been investigated.

11. Petal Color. Bailey stated that the petals of *B. oleracea*, *B. napus*, and allied species were cream-yellow, very light yellow, ochroleucous, or white, and those of other species were bright yellow or sulphur-yellow. The writer has found that the petals of the *juncea-chinensis* group are not always bright yellow or sulphur-yellow. The petals of the new type of *B. chinensis*, pe-hwa piao-er-tsai, are white, but at the point of inflection of the claw there is a very light yellow color. In addition to this type, other types of white petals have been found in the *juncea-chinensis* group. Petals have often been found in Meitan siao-yu-tsai (*B. chinensis* var. *pandurata*) which are not so white as those of pe-hwa piao-er-tsai, with a little more yellow pigment distributed throughout the petal. Another sort of white petal is found in Meitan da-yu-tsai (*B. juncea* var. *gracilis*); its appearance is much like that of white-flowered siao-yu-tsai. A cross of white-petaled siao-yu-tsai × normal yellow results in normal yellow F_1 and a ratio of 3 yellow to 1 white in F_2. The yellow of the F_2 segregates is not uniform; three grades—intensified yellow, normal yellow, and greenish-yellow—may be identified. Similarly two grades—parental white and yellowish-white—may be identified among the white-petaled progeny.

The F_1 of white-petaled da-yu-tsai × normal yellow has also been obtained. The petal color of the hybrid is normal yellow. A ratio of 12 normal yellow: 3 light yellow: 1 parental white is obtained in the F_2 generation when the F_1 plants are selfed. This suggests a 2-gene hypothesis.

Petals of the F_1 plants of pe-hwa piao-er-tsai × yellow-petaled wild type siao-yu-tsai are lemon-yellow. When the F_1 was selfed, 14 normal yellow, 2 lemon yellow, and 5 white were obtained. The backcross progeny of pe-hwa piao-er-tsai × F_1 resulted in 33 lemon-yellow and 22 white-petaled plants. White petal of piao-er-tsai may differ from wild type yellow petal by a single gene.

Pearson (1929) and Kakizaki (1930), working independently on material from different sources, have reached the same conclusion, that the white corolla of *B. oleracea* is conditioned by a single dominant gene *Wh*, yellow being recessive. As regards the white-petaled form, Bailey considered it as a species under the name *B. alboglabra*. As far as evidence is available, such simply inherited differences, though of considerable interest, cannot be regarded as of taxonomic value, and exclusion of them in the delimitation of species will remove the most serious anomalies from the older classification. It is possible to select from commercial crops heterozygous plants of white-flowered *B. alboglabra* which will give progenies consisting of 75 per cent white-flowered *B. alboglabra* and 25 per cent yellow-flowered *B. oleracea*—two species within a single commercial variety.

12. Length and Shape of Silique. According to the writer's observations of the last three years, length and shape of silique should be considered as among the major taxonomic characters of *Brassica*. Classification of species based upon this character is found quite satisfactory. The siliques of all species of *Brassica* are essentially glabrous, but those of *Sinapis alba* are densely covered with stiff setose hairs. This should be regarded as one of the typical differences between *Brassica* and *Sinapis*. Also the silique of *Sinapis alba* is sharply constricted in the center and has seven ridges on each of the two valves (fig. 1, h). These also should be considered as major taxonomic characters. Moreover, the siliques of *B. nigra*, *B. juncea*, and *B. carinata* are all 4-sided, especially those of *B. nigra*; with no extra ridges except the four distinct edges (fig. 1). The external constrictions of these three species are not so prominent as those of *Sinapis alba*. The siliques of *B. chinensis, B. oleracea*, and *B. napus* are all practically glabrous; no distinct ridges can be found on their surfaces and they are elliptic in cross section.

TABLE 8. *Mean length of silique in 22 specimens of Brassica (1941).*

Name	Mean length (mm.)	Name	Mean length (mm.)
Yellow-flowered kale	71.4	Meitan da-yu-tsai	31.7
Red kohlrabi	67.8	Snowball turnip	31.7
White flowered kale	57.2	Horsetail da-yu-tsai	31.5
Green kohlrabi	54.4	Tson-tsai	31.4
Rutabaga	54.8	Ling-chiao-tsai	31.1
Meitan siao-yu-tsai	44.8	Ishan long-petioled	30.8
Chi-cho yieh da-tou tsai	37.9	Kwangsi long-petioled	27.5
Pe-pa-yieh da-tou-tsai	34.9	Chou-chow chieh-tsai	27.4
Kiangmen pe-tsai	34.6	Nanfeng chieh-tsai	25.6
Meitan hwangi-ya-tsai	33.2	Pe-hwa piao-er-tsai	20.2
Kweilin hwa-tsai	32.7	Shealiehung chieh-tsai	20.2

Significant difference at 5% point: 6.36 mm.

Considering the length of silique exclusive of the beak, one finds very remarkable differences among species (tables 8–10). Ten random measurements in each of 22 specimens and 20 measurements in each of 5 species of *Brassica* were made in 1941 and 1943 respectively. In 1944, 10 random measurements in each of 15 specimens were made. The differences necessary for significance were determined by analysis of variance. The variance between species or varieties were significantly greater than that within each class, indicating real differences among the species and varieties of *Brassica*.

The siliques of *B. nigra* and *Sinapis alba* are significantly shorter than those of any other species. Bailey mentioned that the fruit of *B. nigra* is short, less than 1 inch long, and that of *Sinapis alba* 0.75–1.5 inches long. However, the writer has not found one fruit of *Sinapis alba* which exceeded 15 mm. in length in samples taken over two years, and no silique of *B. nigra* was found to exceed 14 mm. in length.

TABLE 9. *Mean length of silique in 5 species of Brassica (1943).*

Species	Mean length (mm.)
B. nigra	11.0
Sinapis alba	12.0
B. juncea var. *gracilis*	29.2
B. carinata	30.0
B. napella	48.5
Significant difference at 5% point: 1.65 mm.	

It can be seen from table 10 that the lengths of siliques of different species of *Brassica* are quite variable in nature. The range of variation may be as small as 3 mm., as in *B. nigra*, and as large as 41 mm., as in hwang-ya-tsai. High variability is associated with long siliques and low with short. It would be unfair to use a generalized experimental error for comparing different species-means within certain large-silique groups or within certain small-silique groups. On account of this relation, three groups—large-, medium-, and small-silique groups—have been separated according to the range of variation and the mean lengths of silique. Analysis of these groups gave quite different variances within species.

In general, the siliques of the 9- and 19-chromosome species are very long.

TABLE 10. *Ten random measurements of length of silique in each of 15 specimens of Brassica (1944).*

Name	Lengths of silique (mm.)										Mean length (mm.)
B. napus	68	68	61	58	71	66	61	59	42	45	59.9
B. napobrassica	53	53	51	55	55	53	57	49	50	38	51.4
B. oleracea var. *acephala*	60	62	75	73	73	76	74	61	62	54	67.0
B. campestris	60	60	52	54	47	43	44	42	30	22	45.4
Hwang-ya-tsai (special)	69	69	70	72	54	52	43	40	37	31	53.7
Significant difference at 5% point for above: 9.67 mm.											
Da-chieh-tsai	40	40	42	39	39	33	38	39	33	25	36.8
Da-yu-tsai	31	33	33	31	32	35	30	31	33	23	31.2
B. carinata	35	35	34	32	33	27	31	26	22	18	29.3
B. campestris	36	34	37	36	35	26	27	28	19	38	31.6
Extra early purple top	23	32	35	31	42	47	48	41	31	25	35.5
Siao-yu-tsai	37	38	35	37	38	40	35	30	22	20	33.2
Pe-hwa piao-er-tsai	27	25	26	27	28	24	26	21	21	18	24.3
Significant difference at 5% point for above: 5.28 mm.											
B. nigra	10	13	12	10	11	11	10	12	12	11	11.2
Sinapis alba	7	13	12	12	13	10	12	11	11	12	11.3
Shealiehung chieh-tsai	17	20	18	21	20	20	19	20	18	18	19.1
Significant difference at 5% point for the above: 1.28 mm.											
Significant difference at 5% point for all species: 6.56 mm.											

The mean lengths range from 48.5 mm. in *B. napella* (table 9) to 71.4 mm. in yellow-flowered kale (table 8). But the mean lengths of silique of nearly all varieties of *B. juncea, B. chinensis, B. rapa,* and *B. carinata* are rather short, from 19.1 mm. in Shealiehung chieh-tsai (table 10) to 37.9 mm. in chi-cho-yieh da-tou-tsai (table 8). Table 8 shows that the mean length of siliques of Meitan siao-yu-tsai is 44.8 mm., which is significantly less than the mean length of the siliques of rutabaga or green kohlrabi but greater than that of chi-cho-yieh da-tou-tsai. As shown in table 10, the mean length of siliques of another type of siao-yu-tsai in Meitan is 33.2 mm., which is also significantly less than that of the long-silique species but not significantly different from that of the medium-silique species. In which group should Meitan siao-yu-tsai be included? In a study of correlation of characters of siao-yu-tsai in Hangchow, Sun and Chon (1930) reported the estimated mean length of the siliques, including the beak, as 57.1 mm. The estimated standard deviation was 11.7 mm. and the range of variation 30.1–95.0 mm. Considering these data, it seems safe to include siao-yu-tsai in the long-silique group.

The variation in silique-length of different types of *B. campestris* and of hwang-ya-tsai is also great. Identification of these species should only doubtfully be based on silique-length alone.

It follows from present data that species of *Brassica* may generally be placed in three groups according to silique-length:

1. Short-silique group; mean length 11.0–12.0 mm.; range of variation 7–15 mm.; species: *B. nigra, Sinapis alba.*
2. Medium-silique group; mean length 19.1–37.9 mm.; species: *B. campestris, B. rapa, B. chinensis, B. juncea, B. carinata.*
3. Long-silique group; mean length 44.8–71.4 mm.; species: *B. oleracea, B. napus* (*B. napella*), *B. campestris, B. chinensis* var. *pandurata* and var. *pekinensis.*

13. Length and Shape of the Beak of Silique. Length and shape of beak should also be considered as important taxonomic characters. Bailey used this character to separate *Brassica* (*Sinapis*) *alba* from other species. He placed *B. nigra* and all 10- and 18-chromosome species under the heading "beak of mature silique slender or conical, terete in section, not seed-bearing," while *B. alba* is found under the heading "beak of mature silique long and flat or two-edged, usually or often containing a seed in the indehiscent cell." The above distinction may generally be considered correct, but the writer has found no seed in the beak of *Sinapis alba;* it is essentially flat, scythe-shaped, equaling or exceeding the fruit body, in these ways quite different from all species of *Brassica* proper.

Bailey also pointed out that the beak of *B. napus* is mostly more than

TABLE 11. *Mean length of beak in 22 specimens of Brassica (1941).*

Name	Length of beak (mm.)	Name	Length of beak (mm.)
Meitan siao-yu-tsai	19.7	Red kohlrabi	7.7
Rutabaga	11.7	Common da-tou-tsai	7.6
Yellow-flowered kale	11.3	White-flowered kale	7.4
Snowball turnip	9.3	Nanfeng chieh-tsai	7.4
Kiangmen pe-tsai	9.1	Chi-cho-yieh da-tou-tsai	7.3
Horsetail da-yu-tsai	8.8	Tson-tsai	7.3
Kwangsi long-petioled	8.7	Shealiehung chieh-tsai	6.9
Ishan long-petioled	8.7	Chou-chow chieh-tsai	6.9
Meitan hwang-ya-tsai	8.1	Kweilin hwa-tsai	6.3
Meitan da-yu-tsai	8.0	Ling-chiao-tsai	5.3
Green kohlrabi	7.9	Pe-hwa piao-er-tsai	4.9

Significant difference at 5% point: 1.87 mm.

TABLE 12. *Mean length of beak in 5 species of Brassica (1943).*

Species	Mean length of beak (mm.)
B. nigra	2.9
Sinapis alba	14.9
B. juncea var. *gracilis*	6.7
B. carinata	3.6
B. napella	17.3

Significant difference at 5% point: 0.87 mm.

TABLE 13. *Mean length of beak in 15 specimens of Brassica (1944).*

Name	10 measurements of length of beak (mm.)										Mean
B. napus	16	18	16	16	16	16	17	15	14	16	16.0
B. napobrassica	12	12	11	10	12	12	11	11	12	9	11.2
B. campestris (1)	25	24	23	25	20	17	13	11	13	10	18.1
Extra early purple top	8	10	19	18	22	19	18	16	13	10	15.3
B. campestris (2)	18	14	18	16	18	12	11	11	10	17	14.5
Hwang-ya-tsai (special)	11	12	14	14	11	9	10	8	6	8	10.3
Sinapis alba	10	15	14	14	15	12	13	14	13	14	13.4

Significant difference at 5% point of above: 3.04 mm.

B. oleracea var. *acephala*	8	8	7	6	7	7	8	6	7	5	6.9
Siao-yu-tsai (var. *pandurata*)	6	7	6	5	6	6	4	5	3	3	5.1
Pe-hwa piao-er-tsai	6	7	8	7	8	6	6	4	5	4	6.1
Da-yu-tsai (var. *gracilis*)	8	8	8	9	9	10	8	9	6	7	8.2
Shealiehung chieh-tsai	5	4	6	6	6	6	7	6	4	6	5.6
Ba-chieh-tsai (*rugosa*)	9	9	8	8	7	7	8	8	6	7	7.7
B. carinata	4	4	3	3	4	3	3	3	4	3	3.4
B. nigra	2	3	3	3	3	3	3	3	3	4	3.0

Significant difference at 5% point for above: 0.92 mm.
Significant difference at 5% point for all species: 2.16 mm.

1 cm. long, that of *B. napobrassica* usually less than 1 cm., and that of *B. napiformis* less than 8 mm.

For a study of the length of the beak, 10 random measurements in each of 22 specimens, 20 measurements in each of 5 species, and 10 measurements in each of 15 specimens of *Brassica* were made in 1941, 1943, and 1944 respectively (tables 11–13).

The mean beak-length of specimens examined may be classified in two main groups, a long-beak class and a short-beak class. The long-beak class includes *Sinapis alba*, all 19-chromosome species, and some of the 10-chromosome specimens. The short-beak class includes *B. nigra*, *B. carinata*, all 9- and 18-chromosome specimens, and some of the 10-chromosome specimens. Table 11 shows that Meitan siao-yu-tsai belongs to the long-beak class and the beak-length variation of other specimens including the 9-, 10-, 18-, and 19-chromosome species ranges from 4.9 to 11.7 mm. There is practically no clear-cut line in the classification of species; consequently it was thought that the ratio of beak-length to silique-length might be more applicable than beak-length alone in classifying species. This ratio computed for 15 specimens in 1944, 5 species in 1943, and 22 specimens in 1941, is shown in tables 14–16.

TABLE 14. *Silique-beak ratio in 15 specimens of Brassica in 1944.*

Name	Mean silique–beak ratio based on 10 computations	Range of variation
Sinapis alba	0.8	0.2
B. rapa	2.4	1.4
B. campestris (1)	2.6	1.7
B. campestris (2)	2.2	0.6
Significant difference at 5% point for above: 0.35.		
B. napus	3.7	1.6
B. napobrassica	4.6	1.3
Hwanga-ya-tsai (special)	5.3	2.3
Pe-hwa piao-er-tsai	4.1	2.0
Da-yu-tsai	3.9	2.2
Da-chieh-tsai	4.8	2.0
Shealiehung chieh-tsai	3.5	2.3
B. nigra	3.8	2.2
Siao-yu-tsai	6.7	3.3
Significant difference at 5% point for above: 0.55.		
B. oleracea var. *acephala*	9.8	4.7
B. carinata	8.7	5.8
Significant difference at 5% point for above: 1.58.		
Significant difference at 5% point for all specimens: 0.71.		

The variation of the silique-beak ratio is essentially continuous and no clear-cut line can be drawn to separate groups. One outstanding feature

TABLE 15. *Mean siliqeu–beak ratio in 5 species of Brassica (1943).*

Species	Mean silique–beak ratio
B. nigra	4.0
Sinapis alba	0.8
B. juncea var. *gracilis*	4.4
B. carinata	8.4
B. napella	2.8

Significant difference at 5% point: 0.49.

should be mentioned: the mean silique-beak ratio of *Sinapis alba* was found to be 0.822 and 0.841 in 1943 and 1944 respectively, definitely showing that the beak length exceeds the silique length. This should be regarded as an identifying character which does not occur in other species.

Kohlrabi, kale, and *B. carinata* may be considered as the short-beak species in terms of silique length. Some types of Meitan siao-yu-tsai, *B. campestris,* and the extra early purple top turnip may be considered as the long-beak type. Other specimens, including *B. nigra, B. napus,* rutabaga, and varieties of *B. chinensis* and of *B. juncea* can hardly be separated by silique-beak ratio.

14. Angle between Pedicels and Rachis. It is found in *Brassica* that the angle between pedicels and rachis differs in different species. Pedicels of *B. nigra* are closely appressed to the rachis, and Bailey has considered this as typical of that species. The writer has found that this character is not confined to *B. nigra* but is found also in *B. juncea.* Horsetail da-yu-tsai (*B. juncea* var. *orthocarpa*) is characterized by the same sort of ascending pedicels as *B. nigra.*

Besides the extreme type of *B. nigra,* the angle between pedicels and rachis varies widely in other species. The pedicels of *B. napella* and *Sinapis alba* are practically perpendicular to the rachis; while in other species different angles are found in different varieties. For a study of the variation in

TABLE 16. *Mean silique–beak ratio in 22 specimens of Brassica (1941).*

Name	Mean ratio	Name	Mean ratio
Meitan siao-yu-tsai	2.3	Pe-hwa piao-er-tsai	4.1
Shealiehung chieh-tsai	2.9	Tson-tsai	4.3
Kwangsi long-petioled	3.2	Common da-tou-tsai	4.6
Snowball turnip	3.4	Rutabaga	4.7
Ishan long-petioled	3.5	Kweilin hwa-tsai	5.2
Nanfeng chieh-tsai	3.5	Chi-cho-yieh da-tou-tsai	5.2
Horsetail da-yu-tsai	3.6	Ling-chiao-tsai	5.9
Kiangmen pe-tsai	3.8	Yellow-flowered kale	6.3
Meitan da-yu-tsai	4.0	Green kohlrabi	6.9
Chou-chow chieh-tsai	4.0	White-flowered kale	7.7
Meitan hwang-ya-tsai	4.1	Red kohlrabi	8.8

TABLE 17. *Mean angles between pedicels and rachis in 3 specimens of Brassica (1941).*

Name	Mean angle (based on 20 measurements)
Meitan siao-yu-tsai	65.2°
Meitan da-yu-tsai	48.0°
Horsetail da-yu-tsai	14.7°

Significant difference at 1% point: 9.298°.

this angle, 20 measurements in each of three specimens were made in 1941. Table 17 indicates that the mean angle formed between pedicels and rachis in horsetail da-yu-tsai is acute, which means that the silique is appressed to the rachis. Meitan siao-yu-tsai represents the wide-spreading type but the angle does not reach 90 degrees. Meitan da-yu-tsai represents the intermediate type, the angle being about 45°.

15. Number of Seeds per Silique. It has been pointed out that the length of silique may be considered important in the classification of species of *Brassica*. It is easily realized that the number of seeds per silique may also be of use. Sun and Chou (1930) reported that the mean number of seeds per silique in Hangchow siao-yu-tsai, estimated from 87 individuals, was 32.89; the estimated standard deviation was 3.8, and the total range of variation 24–42. For a study of the variation in number of seeds per silique, 10 random counts in each of 6 and 15 specimens of *Brassica* were made in 1943 and 1944 respectively. It can be seen from tables 18 and 19 that significant variation in number of seeds per silique occurs in different species. Analogous to the silique-length groups, three groups may generally be separated according to the mean number of seeds per silique, as follows:

1. Small-silique group; seeds per silique from 1 to 8; mean number of seeds 3.3–5.6; species included: *B. nigra*, *Sinapis alba*.
2. Medium-silique group; seeds per silique from 9.6 to 20.6; species included: *B. campestris*, *B. chinensis*, *B. carinata*, and *B. juncea*.

TABLE 18. *Number of seeds per silique in different species of Brassica (1943).*

Species	10 random counts										Mean
B. alba	3	4	2	4	4	4	4	3	5	5	3.8
B. nigra	6	3	5	5	8	7	5	6	4	7	5.6
B. carinata	14	7	12	13	13	12	10	8	8	15	11.2
Da-yu-tsai	18	14	14	14	13	14	13	16	14	15	14.5
Siao-yu-tsai	23	22	23	23	23	23	27	14	11	17	20.6
B. napella	26	27	27	26	14	17	29	27	23	24	24.0

Significant difference of means at 5% point: 2.86.

3. Large-silique group; seeds per silique from 24 to 30.6; species included: *B. oleracea*, *B. napus* (*B. napella*), and *B. chinensis* var. *pandurata*. (In Hangchow siao-yu-tsai, the range of variations was from 24 to 42 seeds per silique.)

16. Color and Size of Seeds. Color and size of seeds of different species and varieties of *Brassica* vary greatly. Sun (1937) examined the variation in weight of 50 seeds in relation to seed color of inbred lines of Hangchow siao-yu-tsai. His results are reproduced in table 20. They distinctly indicate a wide variation in seed size among these inbred lines. A test for independence of the data gave $X^2 = 11.637$. For 5 degrees of freedom p would fall between 0.05 and 0.02, indicating that an association exists between seed color and seed size, large seed being associated with yellow and small seed with red or purple color.

TABLE 19. *Number of seeds per silique in different species of Brassica (1944).*

Name	10 random counts										Mean
Hwang-ya-tsai (special)	25	30	25	30	14	8	6	4	5	2	14.9
Meitan siao-yu-tsai	24	25	23	21	24	30	22	17	3	3	19.2
B. campestris (1)	17	27	22	27	16	19	28	23	2	4	18.5
Extra early purple top	3	5	9	8	10	23	16	12	5	5	9.6
B. campestris (2)	17	20	20	19	21	5	10	11	4	19	14.6
B. carinata	15	15	18	15	13	12	11	11	5	4	11.9
B. juncea var. *rugosa*	17	20	18	16	14	11	20	19	16	6	15.7
Pe-hwa piao-er tsai	21	20	16	17	21	15	16	13	11	8	15.8
B. juncea var. *gracilis*	14	16	13	14	14	15	16	15	16	6	13.9
Significant difference of means of above at 5% point: 6.25.											
B. napus	31	35	27	21	34	30	26	25	11	14	25.4
B. napobrassica	29	23	30	28	28	24	31	22	25	13	25.3
B. oleracea var. *acephala*	26	27	36	38	33	38	36	28	25	19	30.6
Significant difference of means of above at 5% point: 6.14.											
B. nigra	5	6	4	5	4	4	3	5	5	5	4.6
Sinapis alba	1	4	3	4	5	2	3	4	3	4	3.3
Shealiehung chieh-tsai	9	11	9	12	11	8	10	9	8	9	9.6

Significant difference of means of the above at 5% point: 1.04.
Significant difference of means of all species at 5% point: 5.51.

For a detailed study of the variation in seed size of different species and varieties, seed weights were determined for 2 random samples of 50 seeds in each of 44 specimens and 2 random samples of 100 seeds in each of 49 specimens in 1941 and 1943 respectively (tables 21–24). It is seen from table 21 that seed size varies greatly even within groups of the same number of chromosomes. In general, seed size of the 10-chromosome group may be considered as larger than that of the 18-chromosome group (table 23). Table 24 shows

TABLE 20. *Frequency distribution of seed weight in relation to seed color.*

Wt. of 50 seeds (g.)	Number of plants with seeds Purple or red	 Yellow	 Total
0.10–0.13	7	5	12
0.13–0.14	5	6	11
0.14–0.15	17	13	30
0.15–0.16	17	23	40
0.16–0.17	7	13	20
0.17–0.29	9	33	42
Total	62	93	155

TABLE 21. *Mean weight of 50 seeds and seed color of different species and varieties of Brassica (1941).*

Name	Seed color	Weight of 50 seeds	Calculated for 100 seeds
Green kohlrabi	Purple	0.22	0.45
Red kohlrabi	Purplish-brown	0.15	0.30
White-flowered kale	Purplish-black	0.14	0.29
Yellow-flowered kale	Purplish-black	0.13	0.26
Rutabaga	Purplish-black	0.10	0.21
Siao-yu-tsai (1)	Yellow	0.20	0.40
Siao-yu-tsai (2)	Yellow	0.17	0.35
Siao-yu-tsai (3)	Yellow	0.17	0.35
Siao-yu-tsai (4)	Purplish-brown	0.15	0.30
Siao-yu-tsai (5)	Yellow	0.15	0.30
Siao-yu-tsai (6)	Yellow	0.14	0.29
Siao-yu-tsai (7)	Purplish-brown	0.14	0.29
Long-petioled pe-tsai	Purplish-black	0.10	0.20
Kweilin hwa-tsai (1)	Purplish-brown	0.10	0.21
Tze-kiang siao-yu-tsai	Purplish-black	0.09	0.18
White-petaled siao-yu tsai (1)	Yellow	0.09	0.18
Pe-hwa piao-er-tsai	Reddish-brown	0.09	0.17
Kweilin hwa-tsai (3)	Purplish-brown	0.08	0.17
Kweilin hwa-tsai	Purplish-brown	0.08	0.16
Loehsiang siao-yu-tsai	Purplish-black	0.08	0.16
Hybrid turnip	Purple	0.07	0.14
Yüanlin siao-yu-tsai	Purplish-black	0.07	0.14
White-petaled siao-yu-tsai (1)	Yellow	0.07	0.13
Pe-tsai	Purplish-black	0.07	0.13
Siontan siao-yu-tsai	Purplish-black	0.06	0.13
30-day early tsai-tai	Purplish-brown	0.06	0.13
Kasin short-petioled	Purplish-brown	0.06	0.12
Snowball turnip	Purplish-brown	0.04	0.08
Ling-chiao-tsai	Purplish-black	0.08	0.16
Da-tou-tsai	Brown	0.08	0.16
Chou-chow chieh-tsai	Brown	0.07	0.13
Red-leaf chieh-tsai	Black	0.07	0.13
Dinfan (4) da-yu-tsai	Purplish-brown	0.07	0.13
San-yeu-chin chieh tsai	Purple	0.06	0.13
White-petaled da-yu-tsai	Yellow	0.06	0.13
Horsetail da-yu-tsai	Brown	0.06	0.13
Hsu-pu da-yu-tsai	Purplish-brown	0.06	0.12
Ping-yeu da-yu-tsai	Purplish-brown	0.05	0.11
Yellow-leaf chieh-tsai	Purplish-brown	0.05	0.10
Nanfeng chieh-tsai	Purplish-brown	0.04	0.08
Wild da-yu-tsai	Reddish-brown	0.04	0.09
Ping-yeu (1) da-yu-tsai	Purplish-brown	0.04	0.09
Shealiehung chieh-tsai	Brown	0.04	0.08
Tson-tsai	Brown	0.03	0.05

TABLE 22. *Frequency distribution of seed weight in relation to number of chromosomes (1941).*

Weight of 100 seeds (g.)	Number of varieties having		Total
	$n = 10$	$n = 18$	
0.05–0.12	2	7	9
0.12–0.16	7	9	16
0.16–0.20	5	0	5
0.20–0.32	6	0	6
0.32–0.40	3	0	3
Total	23	16	39

TABLE 23. *Weight of 100 seeds in each of 49 varieties of rape (1943).*

Name	Seed color	Mean wt. of 100 seeds (g.)
Siao-yu-tsai (y × w) F_2	Yellow	0.38
Siao-yu-tsai (1)	Yellow	0.37
Siao-yu-tsai (2)	Yellow	0.36
Siao-yu-tsai (70)	Yellow	0.33
Siao-yu-tsai × Kweilin hwa-tsai F_2	Purple	0.33
Siao-yu-tsai (3)	Yellow	0.32
Ishan siao-yu-tsai	Purple	0.32
Bitter siao-yu-tsai	Purple	0.32
Siao-yu-tsai (y × p) F_2	Yellow & purple	0.31
Yuanlin siao-yu-tsai	Purple	0.30
Szermen siao-yu-tsai	Purple	0.30
Tze-kiang siao-yu-tsai	Purple	0.30
Lu-chie siao-yu-tsai	Purple	0.30
White-petaled siao-yu-tsai	Yellow	0.30
Lei-hsiang siao-yu-tsai	Purple	0.29
Siontan siao-yu-tsai	Purple	0.29
Pe-hwa piao-er-tsai × siao-yu-tsai F_2	Purple	0.27
Pe-hwa piao-er-tsai × wild siao-yu-tsai F_2	Purple	0.21
Siao-yu-tsai commercial	Yellow	0.20
B. napella	Deep purple	0.25
Da-yu-tsai dinfan (4)a	Deep purple	0.27
Da-yu-tsai pinyeh (2)	Deep purple	0.24
Da-yu-tsai commercial (1)	Purple	0.22
Da-yu-tsai (101)	Yellow	0.22
Da-yu-tsai commercial (2)	Yellow	0.22
Da-yu-tsai pinyeh (4)	Purple	0.22
Da-yu-tsai hwanpin (2)	Purple	0.22
Da-yu-tsai loo-dieh (1)	Purple	0.21
Da-yu-tsai (104)	Yellow	0.21
Da-yu-tsai dinfan (4)b	Purple	0.21
Da-yu-tsai changsei (4)	Purple & yellow	0.21
Da-yu-tsai (106)	Yellow	0.21
Da-yu-tsai (110)	Yellow	0.20
Da-yu-tsai (96)	Yellow	0.20
Da-yu-tsai commercial	Yellow	0.20
Da-yu-tsai (107)	Yellow	0.20
Da-yu-tsai pingchow (2)	Purple	0.20
Da-yu-tsai kwenlin (2)	Purple	0.20
Da-yu-tsai pinyeh (1)	Purple	0.19
Da-yu-tsai (102)	Yellow	0.19
Da-yu-tsai sze-pim (2)	Purple	0.18
Horsetail da-yu-tsai	Yellow	0.18
Da-yu-tsai shepu sweet	Purple	0.18
White-petaled da-yu-tsai	Yellow	0.17
(Tson-tsai × da-yu-tsai) F_2	Purple	0.16
(Shealiehung × white-petaled da-yu-tsai) F_2	Purple	0.15
(Tson-tsai × Shealiehung) F_2	Purple	0.14
Tson-tsai	Purple	0.14
Shealiehung	Purple	0.13

significant variation in seed size among the 49 varieties tested. Analogous to the 1941 results, variation is also great within groups having the same number of chromosomes (table 25).

TABLE 24. *Frequency distribution of seed weight in relation to number of chromosomes of two Chinese species of rape (1943).*

Weight of 100 seeds	Number of varieties having $n = 10$	Number of varieties having $n = 18$	Total
0.101–0.15	0	4	4
0.151–0.20	0	12	12
0.201–0.25	2	12	14
0.251–0.30	6	1	7
0.301–0.35	8	0	8
0.351–0.40	3	0	3
Totals	19	29	48

Although there is association between seed size and species groups, owing to the continuous and overlapping distribution of their frequencies the two groups can hardly be separated by seed size alone. Size of seed, therefore, can be considered as only minor for taxonomic purposes.

As to seed color variation, many shades from purplish-black to light yellow have been observed in both 10- and 18-chromosome species. The presence or absence of pigment and its genetic nature were not investigated until recently. Varietal crosses were made between yellow and purple seed-types of *B. juncea* in the spring of 1941. Breeding experiments have shown that purple was dominant over yellow, as indicated by the phenotype of the F_1 hybrid. In certain F_2 populations, a segregation of 15 purple and red to 1 yellow was obtained. Another population showed a ratio of 3 red to 1 yellow. A back cross progeny of the yellow-seeded parent by an F_1 plant showed a ratio of 3 red to 1 yellow, which confirms the duplicate factor hypothesis suggested by the F_2.

From the above results it may be safe to conclude that color and size of seed of *B. chinensis* and *B. juncea* can be regarded as useful for identifying agricultural varieties within these two species, but not adequate for differentiation of species in general

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BANISTERIA CAAPI SPRUCE: ITS CHROMOSOMES[1]

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Not a few of the scientifically minded travelers in the Amazonian region have written of *"Caapi": Banisteria Caapi* Spruce. Ducke (1943) states that the pronunciation in *lingua geral* conforms to the spelling *"capi."* And, of course, there are other popular designations for the plant, which is a shrubby vine of the Malpighiaceae. Richard Spruce, in the 1850's, was acquainted with its cultivation as a drug plant by the Indians on the upper tributaries of the Rio Negro in Amazonas, Brazil, at the cataracts of the Orinoco in Venezuela, and in parts of eastern Peru and Ecuador. In a letter about *"Caapi"* Dr. Raymond M. Hann of the National Institute of Health has informed me that "the alkaloid is banisterine and it is identical with harmine," a derivative of one of the Rutaceae. Perhaps the best original account of *"Caapi"* and of the effects of its use by the Indians is that of Spruce (1908). A readable and general summary is given by Lewin (1931), who says that it "evokes mental disorders similar to the effects" of *Datura*.

The lower part of the stem is beaten in a mortar, and, after the woody debris is separated, the remainder is diluted with water and drunk. According to some writers the triturated material is boiled. Also, sometimes, parts of other plants are added to the preparation. The general effects of drinking *"Caapi"* seem to be: fluctuations in temperature, disturbance of sight, vomiting and vertigo, feelings of fear and of boldness, visions of things wonderfully pleasant and beautiful and of things horrible. Spruce (1908) stated: "In two minutes or less after drinking [a certain amount of] it, its effects begin to be apparent. The Indian turns deadly pale, trembles in every limb, and horror is in his aspect. Suddenly contrary symptoms succeed: he bursts into a perspiration, and seems possessed with reckless fury. . . . In about ten minutes the excitement has passed off, and the Indian grows calm, but appears exhausted.'' According to Lewin (1931) Koch-Grünberg, who spent much time in northwest Amazonia, ''drank two small calabashes of the magic liquor. After a short time he experienced, especially when he emerged into darkness, a peculiar scintillation in crude colours before his eyes. When writing, shadows like red flames passed over the paper. The dose was insufficient to enable him to experience the sensations produced in the Indians by this Phantasticum.''

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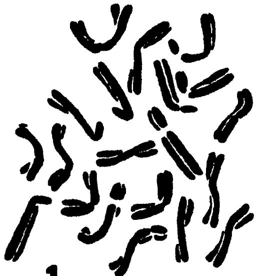
[1] Morton (1930) gave the reasons for accepting the genus *Banisteriopsis* Robinson and (1931) assigned the plant here treated to it. In the latter paper he described *Banisteriopsis inebrians* and discussed its relations to *B. Caapi* and *B. quitensis:* all these are powerful drug plants. Though I know nothing of the merits of specific segregation in this particular aggregate, it is my impression that many groups of tropical plants are over named through a lack of understanding of genetic variation in those groups. And I wonder whether tropical floras—of the Amazonian region, for example—when they are well understood, will prove as rich in species as they now seem: from my own experience with *Hevea* Aubl. throughout much of its distribution area I judge that numerous Amazonian species undergo introgressive hybridization with resultant difficulties for herbarium studies and that many species in that region are characterized by ecotypes which at the hands of systematists are frequently accorded recognition in binomial terms. This is not to imply doubt on my part that hundreds of species await description.

I have seen ''*Caapi*'' cultivated at Cucuhy, at the Venezuelan border, on the Rio Negro, in Amazonas, Brazil; shortly above the mouth of the Rio Uaupés, in Amazonas;[2] at the Campo Experimental, near Manáos, Amazonas, where it had been transplanted by Adolpho Ducke from the Rio Curicuriary, a tributary of the upper Rio Negro (a specimen is in the U. S. National Herbarium: *Ducke 153*); and at Belém, Pará, Brazil. Cuttings from the plants at Cucuhy, Manáos, and Belém are now growing at The Blandy Experimental Farm.



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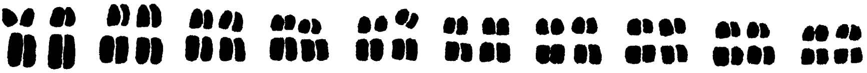

2

Chromosomes of *Banisteria Caapi* Spruce. FIG. 1. Metaphase plate from leaf of Manáos plant (originating from Rio Curicuriary). FIG. 2. Alignment of metaphase chromosomes from a colchicined leaf of Cucuhy plant. From preparations and drawings by Bernice M. Speese. Magnification *ca.* × 2000.

The plants have not flowered in our greenhouse. No vegetative differences have been observed. Ducke (1943) described a new genus and species—*Cabi paraensis*—from plants cultivated at Belém, Pará, which, in a sterile condition, are distinguished from *B. Caapi* only by the thinner leaves of the latter. He states that the people of Pará "ignore" the narcotic properties of *Banisteria*. However, the native from whose house I obtained *"Caapi"* in Belém told me that a drink was made from it and that its leaves were bruised in water used for bathing. No other record of *"Caapi"* for ablutionary purposes has been encountered, and this report may be without significance.

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[2] In March, 1944, at Trovão on the Rio Uaupés, illness prevented my attending an all-night *fiesta* held by the Indians. When, after daybreak, I entered the house in which the celebration was still in progress, an Indian—just as recorded by Spruce almost a hundred years earlier—ran stumblingly from the opposite end of the house to offer me a calabash of what I think was ''*Caapi*''; because of my condition, I refused the drink. The crowd was orderly and rather gay; they had been somewhat noisy during the night. Everybody there appeared to have been dusted with a white, flour-like substance.

Under favorable conditions the plant is a rampant grower. At the Campo Experimental in Manáos *"Caapi"* is at intervals crudely hacked to prevent its too great spread. If a considerable supply of the drug were needed, it could be readily produced.

With the assistance of Bernice M. Speese the chromosomes of three collections of *Banisteria Caapi* at The Blandy Experimental Farm have been examined in leaf smears. They all have a 2*n*-number of 20 chromosomes, with median or submedian constrictions (figs. 1, 2). The material is cytologically difficult, but with the use of colchicine excellent preparations were made. It was hoped that there would be polyploid differences having possible correlation with drug content.

No chromosome-number records for the Malpighiaceae have been found in the literature. Nuclear divisions in which chromosomes are represented have been published for *Galphimia* and *Malpighia* by Stenar (1937), for *Malpighia* by Narasimhachar (1938), and for *Hiptage* by Subba Rao (1940): these authors were interested in megasporogenesis and embryo-sac development but gave no attention to chromosomal detail.

SUMMARY

An account of *Banisteria Caapi* Spruce as a drug plant of the Amazonian Indians is given. The chromosomes of three cultivated plants from different sources were examined: the 2*n*-number is 20; the chromosomes have median or submedian constrictions. The plants studied did not differ vegetatively; they were not brought to flower. No other chromosome-number reports are known for the Malpighiaceae.

THE BLANDY EXPERIMENTAL FARM
BOYCE, VIRGINIA

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STUDIES IN THE SAPOTACEAE—V. THE SOUTH AMERICAN SPECIES OF CHRYSOPHYLLUM

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In continuation of my studies on the American *Sapotaceae*, under the auspices of the Chicle Development Company, I have undertaken a revision of the South American species of *Chrysophyllum*. Thirty species are here recognized, two of which are known to me only from the original descriptions. Three new species are described. The species are, in general, well marked and sharply defined, and, with the exception of *C. marginatum*, do not show an unusual amount of intraspecific variability. The number of species still known from only one or a very few collections suggests that others remain to be discovered.

I have tried without success to prepare a reasonable phyletic scheme. Characters which would seem a priori to be primitive, such as attachment of the filaments toward the base of the corolla-tube, instead of at the throat, are rather consistently associated with apparently advanced features, such as villous anthers or long linear seed-scars. The implication of these difficulties is that the primitive species, and the ancestral home of the genus, are to be sought in the old world, where a number of species occur today. This conclusion is in accordance with the fact that several African species of *Chrysophyllum* often show vestigial staminodes (which are only very rarely seen in American plants), and that the primitive genera of the family are in the old world. I have tried to place related species together in the key and text, but the sequence here used has no other phyletic significance.

The failure of some workers to recognize the importance of seed-characters in the family, together with the fact that the seeds of many of the species are unknown, has led to the impression that the genera of the *Sapotaceae* are vague and ill-defined, but, while doubtful species and indefinite boundaries between genera certainly exist, these are of little more significance in proportion to the whole than in many other families. *Chrysophyllum* is distinguished from all other American *Sapotaceae* by the combination of albuminous seeds and lack of staminodes. In the absence of fruit, species of *Chrysophyllum* might be confused with the likewise astaminodial ***Pradosia***, ***Ecclinusa***, and *Oxythece*. ***Pradosia*** may then be distinguished by the abruptly tenuous distal portion of the filaments, which is reflexed in bud, ***Ecclinusa*** by the usual presence of stipules and by its habit, and *Oxythece* by the texture and venation of the leaves. These have the primary lateral veins obscure or impressed above, and not very prominent beneath, and the secondary veins obscure on both sides or, if visible beneath, at least not raised. The lower surface of the leaves is more or less glaucous. Such a venation is rarely found in *Chrysophyllum,* although *C. arenarium* and forms of *C. marginatum* approach it. The glaucous lower leaf-surfaces of most species of ***Oxythece*** find no counterpart in *Chrysophyllum. Chrysophyllum imperiale* has a double bend near the middle of the filaments, but the filaments are of the same texture throughout, and the very large, toothed leaves of the species are enough to distinguish it at a glance not only from ***Pradosia*** but from all other species of *Chrysophyllum.* Other species of *Chrysophyllum* have straight or occasionally flexuous filaments of essentially uniform texture. *Chrysophyllum pricurii* and *C. cuneifolium,* while surely to be included in *Chrysophyllum,* resemble ***Ecclinusa*** in habit, and may indeed be related to that genus.

Nearly 1000 herbarium sheets have been used in this study. I wish to thank the curators of the various herbaria from which specimens were made available. A list of these, together with the abbreviations used for them in citing specimens is appended. In general, all specimens from the larger herbaria are cited, except those, particularly of the more common species, with incomplete data.

A—Arnold Arboretum, Harvard University, Jamaica Plain, Mass.
BG—Department of Agriculture, British Guiana.
C—University of California, Berkeley.
F—Chicago Natural History Museum (Field Museum), Chicago, Ill.
G—Gray Herbarium, Harvard University, Cambridge, Mass.
K—Royal Botanical Gardens, Kew, England.
Mich—University of Michigan, Ann Arbor.
MO—Missouri Botanical Garden, St. Louis.
NA—United States National Arboretum, Beltsville, Md.
NY—New York Botanical Garden.
P—Muséum d'Histoire Naturelle, Paris.
S—Botanical Museum of Stockholm.
US—United States National Herbarium, Washington, D. C.
V—Servicio Botanico, Ministerio de Agricultura, Caracas, Venezuela.
Herbario del Instituto Miguel Lillo, Universidad Nacional de Tucumán, Argentina.
Instituto de Botánica Darwinion, Buenos Aires, Argentina.
Jardín Botánico, Asuncion, Paraguay.
Museo Argentino de Ciencias Naturales, Buenos Aires, Argentina.

The following generic description is drawn solely from American plants, but will of course apply in large part to the genus as a whole.

CHRYSOPHYLLUM L. Sp. Pl. 192. 1753.

Trees or shrubs with milky juice; leaves simple, alternate, entire or rarely toothed, glabrous or more or less hairy, often sericeous beneath, the hairs malphighiaceous, or stalked and bifurcate; venation various, most commonly with the larger secondary lateral veins trending parallel to the primary ones, the areolae with the long axis parallel to the primary lateral veins, but sometimes irregularly reticulate, as in many species of *Pouteria*, or closely striate, as in *Micropholis*, or with prominent secondary veins at right angles to the primary ones, as in *Ecclinusa;* stipules wanting; flowers most commonly in axillary clusters, sometimes at defoliated nodes, 5-merous, or casually 4–6-merous as to sepals, petals, and stamens; sympetalous; stamens as many as the corolla-lobes and opposite them, epipetalous; staminodes wanting, or rarely a few casual and irregularly developed vestiges; ovary with 5 carpels and as many locules, or occasionally with only 4 or as many as 12 carpels and locules; ovules solitary in each locule, attached laterally or basilaterally to the axial placenta; style short, columnar, with obscurely to evidently lobed capitate stigma; fruit fleshy, often edible; seeds solitary or several, with large basilateral or long, narrow or broad lateral scar, this sometimes extending less than half way to the middle, but then very broad; endosperm well developed; embryo with thin cotyledons and well developed caudicle.

Type species: *C. cainito* L.

KEY TO THE SPECIES

1. Anthers glabrous; filaments variously attached.

2. Filaments attached at or below the middle of the corolla-tube; seed scar linear or linear-elliptic, not over about 4 mm. wide, except perhaps in *C. cuneifolium*, whose mature seed is unknown to me.

3. Corolla-lobes about 0.6–0.9 mm. long, truncate, fringed-ciliolate; fruit several-seeded, about 5 cm. thick; seed-scar linear-elliptic, about 4 mm. wide. 1. *C. excelsum.*

3. Corolla-lobes about 1.5–3 mm. long, neither truncate nor fringed ciliolate; fruit various; seed-scar, where known, narrower, seldom over 2 mm. wide.

4. Leaves entire; filaments straight or nearly so.

5. Primary lateral veins mostly well distinguished from the larger secondary ones, the leaf not at all striate; ovary hairy above as well as below.

6. Flowers numerous in clusters on old wood or on defoliated portions of twigs, the pedicels, except in *C. aulacocarpum*, mostly 6–10 mm. long; secondary lateral veins, except perhaps in *C. aulococarpum* (where unknown to me), sinuous, nearly parallel, trending obliquely between or nearly at right angles to the primary ones, the tertiary veins tending to be perpendicular to the secondary ones, though sometimes obscure; Amazon basin and northward.

7. Flowers "subsessile"; fruit ellipsoid, 6 cm. long, 3 cm. thick, single seeded; leaves glabrous; petioles 2–3 cm. long. 2. *C. aulacocarpum.*

7. Flowers on pedicels 6–10 mm. long; fruit globose to depressed-obovoid, as thick as long, several-seeded; leaves and petioles various.

8. Petioles about 20–35 mm. long; leaves rufous-sericeous beneath, eventually glabrate; primary lateral veins mostly 6–12 pair. 3. *C. prieurii.*

8. Petioles about 2–8 mm. long; leaves glabrous, or coarsely strigose on the midrib and main veins beneath; primary lateral veins mostly 12–20 pair. 4. *C. cuneifolium.*

6. Flowers 1–6 in the axils or at recently defoliated nodes, the pedicels about 5 mm. long or less; secondary and tertiary lateral veins forming an irregular reticulum; Ceara to Uruguay, northern Argentina, and southern Bolivia. 5. *C. gonocarpum.*

5. Primary lateral veins not sharply separable from the larger secondary ones, which are parallel to them, the leaf thus appearing somewhat striate, though also reticulate with evident short cross-veins; ovary densely and conspicuously pilose at the base, otherwise glabrous. 6. *C. viride.*

4. Leaves irregularly spinulose-serrate; filaments with a conspicuous double-fold near or above the middle. 7. *C. imperiale.*

2. Filaments attached at the corolla-throat; seed-scar various.

3. Corolla tubular, the lobes about one-fifth to one-half as long as the tube; Amazon drainage and northward.

4. Corolla evidently sericeous.

5. Pubescence of the young twigs and lower leaf surfaces loosely spreading; flowers essentially sessile; Peru. 8. *C. revolutum.*

5. Pubescence strictly appresesd; flowers evidently pedicellate, though sometimes shortly so; general distribution.

6. Leaves merely rufous-strigose beneath when young, later glabrate; hairs of the corolla rufous; primary lateral veins straight or nearly so; leaves 1.5–5 cm. wide. 9. *C. nitidum.*

6. Leaves distinctly sericeous at least when young, sometimes later glabrate; leaves commonly 3.5–11 cm wide, the primary lateral veins usually but not always more or less arcuate toward the margins.

7. Pubescence of the leaves gray or white from the first, sooner or later deciduous; pubescence of the corolla white or merely a little yellowish; northeastern Venezuela, north through the West Indies. 10. *C. argenteum.*

7. Pubescence of the leaves conspicuously yellow or rufous when young, eventually fading, sometimes finally deciduous; pubescence of the corolla rufous; generally distributed in northern South America; not in the West Indies. 11. *C. auratum.*

4. Corolla glabrous.

5. Pedicels, young twigs, and young leaves merely strigose; petioles 3–9 mm. long.

6. Pubescence rufous at first, later fading; corolla about 5–6 mm. long; Venezuela and Colombia. 12. *C. parvulum.*

6. Pubescence white, not at all rufous; corolla 4 mm. long or less; San Martin, Peru. 13. *C. albipilum.*

5. Pedicels, young twigs, and young leaves evidently spreading-hairy, the hairs rufous; petioles 2–3 mm. long; Acre Territory and adjacent Amazonas, Brazil. 14. *C. acreanum.*

3. Corolla campanulate to subrotate, the lobes mostly equaling or exceeding the tube (barely shorter in *C. pavonii*; also shorter in *C. dusenii*, but even then more than half as long as the tube, and the creases extending farther down on the outside); general distribution.

4. Petioles about 2–3.5 cm. long; secondary lateral veins conspicuous, somewhat sinuous, trending obliquely between or at right angles to the primary ones, and sharply distinguished from them; tertiary lateral veins mostly perpendicular to the secondary ones, or obscure. 3. *C. prieurii.*

4. Petioles about 1 cm. long or less; venation various, but not as above.

5. Leaves closely and conspicuously striate, the veins averaging about 0.5 mm. apart; northern Peru. 15. *C. granatense.*

5. Leaves weakly, scarcely, or not at all striate, the veins only 1–2 mm. apart in *C. marginatum*, more distant in the other species.

6. Leaves loosely hairy or nearly glabrous at flowering time, not at all sericeous.

7. Corolla about 3.5–5 mm. long, the lobes distinctly shorter than the tube, as measured from the inside; creases for the corolla-lobes extending about 0.4–0.8 mm. farther on the outside than on the inside, because the lobes are joined within by a thin cylinder of tissue; pedicels 5–11 mm. long. 16. *C. dusenii.*

7. Corolla about 1.7–3.0 mm. long, the lobes equaling or exceeding the tube, about the same length inside as out; pedicels up to 4 mm. or rarely 6 mm. long.

8. Seed-scar basilateral, broad, extending two thirds the length of the seed, or usually less; primary lateral veins rather weak, straight or nearly so, either crowded and only 1–2 mm. apart, making the leaf appear weakly striate, or more distant but with the secondary veins weak and mostly trending parallel to them.

9. Fruit 5–10 (rarely 13) mm. long; seed-scar scarcely extending to the middle of the seed; leaves tending to be weakly striate, varying from rounded or even retuse to acute at the apex, not acuminate. 17. *C. marginatum.*

9. Fruit about 15–20 mm. long; seed-scar about two-thirds as long as the seed; leaves acuminate, not at all striate. 18. *C. ovale.*

8. Seed-scar linear, lateral, extending the length of the seed; primary lateral veins strong, not at all crowded, the leaf not striate; secondary lateral veins forming a coarse and conspicuous irregular reticulum. 19. *C. lucentifolium.*

6. Leaves sericeous or sericeous-tomentose beneath with appressed reddish hairs at flowering time, sometimes eventually glabrate.

7. Stigma evidently 7–12-lobed; pedicels about 5–15 mm. long; fruit 3 cm. thick or generally more, several-seeded; seed-scar lateral, extending nearly the whole length of the seed, very broad; Colombia to Surinam, and northward. 20. *C. cainito.*

7. Stigma obscurely 5–7-lobed; pedicels about 1–3 mm. long; fruit, where known, smaller, less than 2 cm. thick; seeds, where known, with basilateral scar extending only to the middle.

8. Corolla-lobes about twice as long as the tube, or longer; filaments slender, flexuous or variously contorted; French Guiana and eastern Brazil.

9. Primary lateral veins arcuate; secondary lateral veins loosely reticulate, the stronger ones mostly trending at right angles to the primary veins; leaves broadest above the middle; fruit and seed unknown; French Guiana. 21. *C. cochlearium.*

9. Primary lateral veins straight, bifurcate near the margins; secondary lateral veins trending nearly parallel to the primary ones, the larger ones not always sharply separable from them; leaves broadest about at or below the middle; Ceara and Bahia, Brazil. 22. *C. rufum.*
8. Corolla-lobes scarcely equaling the tube; filaments stout, straight; Peru. 23. *C. pavonii.*
1. Anthers villous; filaments attached about at the middle of the corolla-tube, or lower.
2. Leaves spreading-hairy beneath. 24. *C. januariense.*
2. Leaves appressed-hairy or glabrous beneath.
3. Pedicels about 2–3 mm. long; filaments free from the corolla-tube, or nearly so; British Guiana, and Para, Brazil. 25. *C. sparsiflorum.*
3. Pedicels about 5–25 mm. long, except in *C. arenarium;* filaments distinctly attached to the corolla-tube; eastern and southern Brazil, not in the Amazon basin.
4. Leaves permanently and densely sericeous or sericeous-tomentose beneath with strongly rufous hairs.
5. Pubescence rich purplish red; pedicels 15–25 mm. long; leaves about 4–11 cm. long. 26. *C. pulcherrimum.*
5. Pubescence merely coppery-rufous; pedicels about 7–13 mm. long; leaves about 10–30 cm. long. 27. *C. splendens.*
4. Leaves glabrous or finely strigose or sericeous-strigose with whitish hairs beneath, at flowering time, sooner or later glabrate.
5. Leaves about 1.5–6 cm. long, the secondary lateral veins obscure; pubescence of the pedicels and young leaves strongly rufous; pedicels about 2–6 mm. long; corolla only about 2 mm. long. 28. *C. arenarium.*
5. Leaves about 4–40 cm. long, the secondary lateral veins evident; pubescence of the leaves and pedicels white or yellowish, rarely a little rufous in *C. flexuosum;* pedicels about 5–16 mm. long; corolla about 3–7 mm. long.
6. Secondary lateral veins mostly parallel to the primary ones and not sharply separable from them, the lateral veins thus appearing crowded, about 1–3 mm. apart; hairs of the lower leaf surfaces very short and closely appressed, about 0.1–0.3 mm. long. 29. *C. inornatum.*
6. Secondary lateral veins mostly few and loosely reticulate, the primary ones more widely spaced and readily identifiable, about 5–15 mm. apart; hairs longer and merely loosely appressed, about 0.3–0.6 mm. long. 30. *C. flexuosum.*

1. CHRYSOPHYLLUM EXCELSUM Huber, Bol. Mus. Pará **3**: 55. 1902.

Rather large tree; terminal bud sericeous-tomentose with rufous hairs, the leaves probably similarly hairy at first, but very soon glabrate, the blade elliptic or elliptic-obovate, 10–30 cm. long and 5–12 cm. wide, rounded to acutish at the apex; primary lateral veins well-spaced, arcuate; secondary veins fairly regular, becoming perpendicular to the primary ones near the margin; tertiary veins forming a more or less evident reticulum; petioles about 2–4 cm. long; flowers in clusters of about 3–10 at defoliated nodes or in the axils, the pedicels strigose, about 5 mm. long; sepals reniform-orbicular, sericeous-strigose, about 2.9–3.3 mm. long; corolla about 3.8–4.3 mm. long, the lobes broadly oblong, subtruncate, fringed-ciliolate, about 0.6–0.9 mm. long, the creases showing a little farther down the tube on the outside;

filaments attached at or below the middle of the tube, their traces commonly visible to the base; anthers mucronate, about 0.8 mm. long; ovary densely pilose; style glabrous, tapering-columnar, about 2.5 mm. long, nearly lobeless; fruit globose, yellow, about 5 cm. thick; seeds 5 or sometimes fewer, ovate-oblong, about 25 mm. long, 14 mm. wide, and 7 mm. thick, the scar linear-elliptic, about 4 mm. wide, extending nearly the whole length of the seed.

TYPE: Specimens collected from a cultivated tree in Pará, Brazil.

Local names: Sorba do Perú, guajará.

Distribution: Upper Amazon basin, Brazil, to northern Venezuela; presumably also in Peru.

BRAZIL: Pará: *Ducke 602*, Belém do Pará (cult.) (MO, US); *Ducke 15802*, Belém do Pará (cult.) (K, S, US); *Huber 3016*, Belém do Pará (cult.) (US.). Amazonas: *Kuhlmann 21991*, Altamira (NY, US). VENEZUELA: Federal District: *Pittier 13500*, El Limón (F, US).

2. CHRYSOPHYLLUM AULACOCARPUM Ernst, Flora **57**: 214. 1874.

Tree; young twigs slightly rufous-hairy; leaves crowded at the ends of the branches, glabrous, oblong-oval to obovate-oblong, tapering from the middle to the base, about 16–24 cm. long and 9–11 cm. wide; primary lateral veins about 11–14 pair; secondary veins reticulate; petioles about 2–3 cm. long; flowers numerous in clusters at defoliated nodes, subsessile and glomerate; calyx and corolla 4–5-lobed, rufous-sericeous, the corolla about 6–7 mm. across; filaments inserted on the corolla-tube; ovary conic, pentagonal, 5-locular; style short, glabrous; stigma-lobes obscure; fruit ellipsoid, about 6 cm. long and 3 cm. thick, edible, single-seeded; seed ovoid, blackish, shining, about 3 cm. long; seed-scar linear, extending from the base to the apex.

TYPE: *Fermin Toro s.n.*, Los Teques, Venezuela.

Local name: Chupon.

Distribution: Known only from the type collection, Los Teques, Miranda, Venezuela.

The description for this species is taken from the original; I have seen no specimens. It is conceivable that it is conspecific with the later *C. excelsum* Huber, but it seems likely that if it had the characteristic short, truncate, fringed-ciliolate corolla-lobes of that species, that feature would have been noted by Ernst, who gave a fairly complete description. The difference in shape and number of seeds of the fruit, although yet to be proved constant, also suggests that this species is distinct. It should be noted that the *Pittier* collection of *C. excelsum* from Venezuela was taken not far from the type locality of *C. aulacocarpum*. The herbarium specimens are sterile, but bear the collector's note, fruit apple-shaped, yellow. Until further evidence is available, I prefer to retain both names.

3. CHRYSOPHYLLUM PRIEURII A. DC. Prodr. **8**: 161. 1844.

C. cyanogenum Ducke, Trop. Woods 71: 18. 1942.

Large tree sometimes 45 m. tall, pervaded with hydrocyanic acid; twigs coarse, sericeous, the hairs at first rufous, soon fading; leaves clustered toward the ends of the twigs, obovate, rounded to abruptly short-acuminate, about 10–17 cm. long and 5–8 cm. wide, glabrous above, finely and closely rufous-sericeous beneath, but the hairs eventually deciduous and sometimes fading before falling; primary lateral veins mostly 6–12 pair, well-spaced, arcuate; secondary lateral veins somewhat sinuous, nearly parallel and extending obliquely between or nearly at right angles to the primary veins; tertiary lateral veins perpendicular to the secondary ones, or obscure; petioles 2–3.5 cm. long; flowers numerous in dense clusters on the twigs below the leaves, the pedicels rufous-sericeous, 6–10 mm. long, elongating in fruit; sepals rufous-sericeous like the pedicels, rounded, the inner conspicuously fringed-ciliolate, about 2–3 mm. long; corolla about 3.4–4.2 mm. long, glabrous, the lobes reputedly equaling the tube, but in specimens available to me about 3–4 times as long as the tube; filaments reputedly inserted at the middle of the tube, but in specimens available to me inserted at the level of the sinuses, or the stamens sometimes abortive; ovary 5-locular, pubescent with short sub-appressed rufous hairs; style about 0.7 mm. long, hairy below; stigma-lobes 5; fruit yellow, spherical, 3–5 cm. thick, several-seeded, reputedly edible; seeds 15–30 mm. long, 10–15 mm. wide, and 4–7 mm. thick, with a linear scar extending nearly to the summit; endosperm copious.

TYPE: *LePrieur 157*, Cayenne, French Guiana (NY—photo).

Local names: Palo de cuyure (Venezuela); Caran (Colombia); Abiurana (Amazonas, Brazil).

Distribution: French Guiana to Colombia and Amazonas, Brazil.

COLOMBIA: Boyaca: *Lawrence 820*, 130 miles north of Bogotá (K). VENEZUELA: Amazonas: *Williams 14550*, San Carlos de Río Negro (US). SURINAM: *B.W. 3792*, Gonini River (K), *3791* (US). FRENCH GUIANA: *Melinon s.n.* (F, K, P, US); *Melinon 118*, Maroni (K). BRAZIL: Amazonas: *Ducke 813*, Manaos (MO); *Froes 12*, Manaos (Herb. B. A. Krukoff).

The only flowers of this species available to me for dissection were from an isotype of *C. cyanogenum* Ducke, and these differ in certain particulars, as noted above, from Ducke's description. My description of the fruit is taken from that given by Ducke.

4. CHRYSOPHYLLUM CUNEIFOLIUM (Rudge) A. DC. Prodr. 8: 160. 1844.

Bumelia cuneifolia Rudge, Pl. Gui. 1: 30. *pl. 47*. 1805.

Tree; leaves cuneate-oblanceolate, mostly abruptly acuminate, tapering gradually to the base, about 10–25 cm. long and 3.5–8 cm. wide, glabrous, or coarsely strigose on the midrib and main veins beneath, subsessile, the petioles only 2–8 mm. long; primary lateral veins well spaced, arching near the margins, about 12–20 pair; secondary lateral veins fairly regular and nearly parallel, somewhat sinuous, trending nearly at right angles to the primary ones; tertiary veins tending to be perpendicular to the secondary ones; flowers numerous in clusters on old wood, the pedicels about 1 cm. long; sepals about 2.0–2.7 mm. long, conspicuously fringed-ciliate, especially the inner; corolla about 4 mm. long, the lobes three times as long as the tube; filaments attached near the base of the corolla-tube, or half-way up to the sinuses; ovary shortly appressed-hairy; style about 0.5 mm. long; stigma-lobes 5; fruit several-seeded, narrowly sulcate between the seeds, up to 4 cm. long or perhaps more, obovoid or depressed-obovoid.

TYPE: Plants collected in French Guiana (near Cayenne, according to Alphonse DeCandolle), by an unspecified collector, presumably now deposited at the British Museum.

Distribution: French and Dutch Guiana.

SURINAM: *B.W. 1505* (K, US), *1586* (K), *2033* (K), *3939* (K, S), *4384* (US), *5479* (S, US); *Von Hall 89a* (K, Mich, S, US).

5. CHRYSOPHYLLUM GONOCARPUM (Mart. & Eichl.) Engl. Bot. Jahrb. **12**: 523. 1890.

Sapota gonocarpa Mart. & Eichl. ex Miq. in Mart. Fl. Bras. **7**: 60. 1863.

Chrysophyllum cysneiri Freire-Allem. Trab. Comm. Sci. Expl. Bras. Bot. 66. *pl. 18.* 1866.

C. cearense Freire-Allem. op. cit. 72. *pl. 21.*

C. obtusifolium Freire-Allem. op. cit. 74. *pl. 23.*

C. persicastrum Eichl. Kjoeb. Vidensk. Meddel. **1870**: 208. 1871.

C. lucumifolium Griseb. Goett. Abh. **24**: 223. 1879.

Sideroxylon reticulatum Britton, Ann. N. Y. Acad. Sci. **7**: 156. 1893.

Chrysophyllum lucumifolium f. *obtusatum* Chod. & Hass. Bull. Herb. Boiss. II. **7**: 675. 1907.

Sideroxylon bolivianum Rusby, Mem. N. Y. Bot. Gard. **7**: 319. 1927.

Small tree about 4–12 m. tall; leaves rather loosely sericeous-tomentose with white or slightly rufous hairs when young, soon glabrate, elliptic-oblanceolate to occasionally narrowly elliptic or narrowly obovate, broadly obtuse or rounded to occasionally acutish at the apex, mostly 7–18 cm. long and 2–6 cm. wide, often some of them smaller; venation pouterioid, with raised, arching primary lateral veins and a well-developed rather irregular raised reticulum of secondary and tertiary lateral veins; petioles up to about 2 cm. long; flowers about 1–6 in the axils or at recently defoliated nodes, subsessile or on pedicels up to about 5 mm. long, perfect or reputedly sometimes unisexual; sepals thin, light green, rounded, finely sericeous-strigose or subglabrous, about 2.2–3.3 mm. long; corolla about 3.2–3.8 mm. long, the lobes 1.5–2.1 mm.; anthers about 1.1–1.3 mm. long; filaments attached at the base of the corolla-tube, or occasionally joined to it part way up; ovary very densely pilose, the style glabrous, about 1.7–2.0 mm. long, lobeless; fruit yellow, with rather thin sweet edible pulp, 1–5-seeded, sulcate between the seeds, mostly 12–25 mm. (rarely 40 mm.) long; seeds compressed, obliquely obovate, about 10–18 (rarely 30) mm. long; seed-scar linear, about 1–2 mm. wide, extending nearly the whole length of the seed.

TYPE: *Th. Peckolt s.n.*, "prope Canta Gallo, prov. Rio de Janeiro," Brazil.

Local names: Aguay, aguaja (Argentina and Paraguay); Oito bravo (Ceara); Peroba blanco (Rio de Janeiro); Pecigo do mato (Minas Geraes).

Distribution: Ceara, Brazil, southwest to Paraguay, Uruguay, northern Argentina, and southern Bolivia.

BRAZIL: Minas Geraes: *Glaziou 19610* (K); *Regnell 1599*, near Caldas (K); *Warming s.n.* (NY); *Widgren s.n.* (S). Rio de Janeiro: *Glaziou 11143* (K), *11144* (C—photo, G—photo, K, NY—photo). Sao Paulo: *Mosen 3956*, inter Campinas et Vallinhos (S); *Mosen 4241* (S); *Regnell 1599* (S, US). Paraná: *Dusén 10741* (S), *11160* (S); *Dusén 11251*, Theresina (S); *Dusén 17099* (S); *Dusén 17873*, Rio Capinqual (S). Santa Catharina: *Dusén 11819*, Rio Uruguay (S). Rio Grande do Sul: *Leite 1954* (G); *Malme 856*, Porto Alegro (S). BOLIVIA: La Paz: *Rusby 691*, near Huachi, head of Beni River (NY); *Steinbach 7249*, Sara, Río Surutu (S). PARAGUAY: *Balansa 2389* (K), *2391* (K), *4649*

(F); *Fiebrig 458* (A, F, K), *4284* (G, K); *Hassler 3759* (S), *3628* (F, K), *7772* (A, F, K), *11516* (A), *12382* (A, G, MO, K, US); *Jorgensen 3759* (A, G, MO), *3762* (F, G. PA, US); *Lindman A1703*, Asuncion (S); *Malme 994B*, near Rio Apa (S); *Morong 839* (F, K, NY); *Osten 9084*, San Bernardino (S). URUGUAY: *Herter 1606* (C, F, G, MO); *Lorentz 299* (G—photo, NY—photo); *Osten 17998* (US). ARGENTINA: Salta: *Eyerdam & Beetle 22742* (C, G, MO), *22781* (C, G, MO); *Lorentz & Hieronymus 525* (K, NY, S); *Rodriguez 1024* (F, NY); *Schreiter 11496* (Cl, G, NY); *Venturi 5567* (A, C, MO, K, S, US), *7983* (US). Chaco: *Jorgensen 2149* (G, MO). Misiones: *Rodriguez 373* (G, US).

6. CHRYSOPHYLLUM VIRIDE Mart. & Eichl. ex Miq. in Mart. Fl. Bras. **7**: 102. 1863.

Fibrocentrum glazioviannum Pierre, Mém. Bot. Soc. Fr. 3: 441. 1910. Hyponym.

?*Chrysophyllum perfidum* Freire-Allem. Trab. Comm. Sci. Expl. Bot. Rio de Janeiro 1: 68. 1866.

Large tree; leaves oblanceolate or narrowly elliptic, commonly abruptly short-acuminate, sometimes merely acutish or even rounded, about 5–11 cm. long and 15–40 mm. wide, strigose or sericeous-strigose when young, glabrate at maturity, borne on petioles up to 1.5 cm. long; primary lateral veins generally more than 20 pair, not sharply separable from the larger secondary veins, which are parallel to them, the leaf thus appearing striate, but also reticulate with evident cross-veins; flowers several in the axils or at recently defoliated nodes, the pedicels strigose or subglabrous, 4–10 mm. long; sepals rotund, slightly strigose, about 1.7–2.5 mm. long; corolla about 3.0–3.4 mm. long, the lobes a little longer than the tube, reniform-ovate, the tube moderately yellowish-sericeous; filaments attached at or below the middle of the tube, the anthers about 1.1–1.2 mm. long, or in some flowers the anthers wanting and the filaments minute; ovary densely and conspicuously pilose at the base, otherwise glabrous, the style short or obsolete; ovules 5, or in some flowers the ovary more slender or reduced and the ovules wanting; perfect flowers not seen by me, but reputed to exist; fruit ellipsoid-globose, yellow, edible, about 1.5–2.5 cm. thick and up to 4 cm. long; seeds 1–3, somewhat compressed, about 1 cm. wide and 1.5–3 cm. long; seed-scar linear, less than 2 mm. wide, extending the length of the seed; endosperm well developed; embryo with thin cotyledons and evident caudicle.

TYPE: *Schüch s.n.*, eastern Brazil (NY—photo).

Distribution: Rio de Janeiro, Santa Catharina, and Paraná, Brazil, possibly extending as far north as Ceara.

BRAZIL: Rio de Janeiro: *Glaziou 18351* (G—photo, NY). Santa Catharina: *Reitz C–330* (G). Paraná: *Dusén 11994*, Volta Grande (S), *12130*, Desvio Ypiranga (S), *17343*, Tacarehý (S).

Chrysophyllum perfidum Freire-Allem., from Ceara, is probably conspecific with *C. viride*, but differs, according to the original description and figure, in its depressed-globose rather than ellipsoid-globose fruit, with a pronounced areola at the tip, and in its thicker cotyledons and rather scanty endosperm. Allemao reports that it is locally known as goerana.

7. CHRYSOPHYLLUM IMPERIALE (Linden) Benth. & Hook. Gen. Pl. **2**: 653. 1876.

Theophrasta imperialis Linden ex Koch & Fint. Wochenschr. 2: 91. 1859.

Martiusiella imperialis Pierre, Not. Bot. Sapot. 66. 1891.

Small tree with very coarse twigs; leaves cuneate-oblanceolate, obtuse, rounded at the base, irregularly spinulose-serrate, about 15–75 cm. long and 5–25 cm. wide in specimens seen, but reputedly up to a meter or more long, loosely grayish-hirsutulous beneath when young, later glabrate, firm, the midrib coarse and strongly raised beneath; primary lateral veins about 20–50 pair, strongly raised beneath, arcuate toward the margins; secondary and tertiary lateral veins forming a coarse and irregular reticulum, or the secondary veins sometimes perpendicular to the primary ones; petioles about 2–2.5 cm. long; flowers several or numerous in the axils or at defoliated nodes, the pedicels closely hairy, about 5–6 mm. long; sepals rounded, sericeous-tomentose, about 3–4 mm. long; corolla about 4–4.5 mm. long, the rounded-ovate lobes rufous-strigose, equaling or a little exceeding the glabrous tube; minute staminodes sometimes irregularly developed; filaments attached near the base of the corolla-tube, with a conspicuous and persistent double fold near or above the middle; anthers about 1.1–1.5 mm. long; ovary 5-locular, short-hairy, tapering to the summit, the style obsolete, the stigma-lobes obscure; fruit several-seeded, broadly ovoid or subglobose, about 2.5–3.5 cm. long and nearly or quite as thick, tapering to the apex; seeds strongly compressed, about 18–25 mm. long, 13–16 mm. wide, and 6–9 mm. thick; seed-scar linear, 2 mm. wide or less, extending the length of the seed; endosperm copious; embryo with thin cotyledons and well-developed caudicle.

TYPE: Specimens raised from seeds brought from Brazil by Linden.

Local name: Marmelleiro do matto.

Distribution: Rio de Janeiro, Brazil.

BRAZIL: Rio de Janeiro: *Glaziou 8230* (A, F, K, S), *6633*, Serra do Estrello (K), *11163* (K); *7745* (K), *20402* (K).

The double bend in the filaments of *Chrysophyllum imperiale* is reminiscent of *Pradosia*, but in that genus the folded portion is distal and abruptly tenuous, and straightens out as the flower matures, while in *C. imperiale* the fold is near or a little above the middle, and persistent, and the filament is of about the same texture throughout.

8. CHRYSOPHYLLUM REVOLUTUM Mart. & Eichl. ex Miq. in Mart. Fl. Bras. **7**: 104. 1863.

Young twigs densely pubescent with loose short rufous hairs; leaves firm, with revolute margins, elliptic-oblong, 4–9 mm. long, 1.5–4.5 cm. wide, loosely rufous-hirsute on both sides when young, soon glabrate above, and perhaps eventually so beneath; primary lateral veins about 12–15 pair, rather irregularly spaced, bifurcate or arcuate toward the margins; secondary lateral veins few and mostly obscure, trending parallel to the primary ones; petioles about 3–4 mm. long; flowers clustered in the axils or at recently defoliated nodes, essentially sessile; sepals thick and firm, ovate, acute, rufous-hairy, about 1.5 mm. long; corolla about 5 mm. long, densely rufous-sericeous except near the base and at the tips of the lobes, the lobes about one-fourth as long as the tube; filaments short, attached at the level of the sinuses; anthers 0.4–0.5 mm. long; ovary densely rufous-hairy, 5-locular, the style glabrous, about 0.5 mm. long; fruit blackish, insipid, subsessile, ellipsoid-globose, about 12 mm. long, single-seeded; seed-scar basilateral, very broad, extending about two thirds of the way to the top.

TYPE: *Spruce 4260,* "prope Tarapota, Peruvia orientalis," 1855 (F, G, K).

Distribution: Known only from the type locality, in Loreto, Peru.

PERU: Loreto: *Ule 6616,* near Tarapoto, *1902* (K).

9. CHRYSOPHYLLUM NITIDUM G. F. W. Mey. Prim. Fl. Esseq. 116. 1818.

C. psilophyllum A. DC. Prodr. 8: 160. 1844.

Large tree; young twigs slender, rufous-strigose or -sericeous; leaves elliptic or elliptic-lanceolate, acuminate, about 5–12 cm. long and 1.5–5 cm. wide, glabrous and shining above, rufous-strigose beneath when young, later glabrate; primary lateral veins straight or slightly curved, rather weak, about 8–13 pair; secondary lateral veins few, mostly trending parallel to the primary ones; petioles about 5–9 mm. long; flowers several in the axils, the pedicels rufous-sericeous, about 2–6 mm. long; sepals rounded, rufous-sericeous, about 1.3–1.5 mm. long; corolla about 4–5.5 mm. long, the lobes about one-third to one-fifth as long as the rufous-sericeous tube; filaments minute, attached at the level of the sinuses; anthers about 0.4 mm. long; ovary 5-locular, appressed-hairy, tapering to the glabrous style which is less than 1 mm. long; fruit unknown.

TYPE: None given, but stated to grow "in sylvis continentis," presumably near the mouth of the Essequibo River, in British Guiana.

Local name: Kokeritiballi (British Guiana).

Distribution: French Guiana to Colombia.

COLOMBIA: *Mutis 1125* (US). BRITISH GUIANA: "*D.*" *160*, Simuni Creek, Rupurruni River (BG); *Fanshawe 2021*, Mazaruni River (NY). FRENCH GUIANA: *Martin 255* (F, G. K, NY, US); *Poiteau s.n.* (F); *Sagot 845* (F, K, P, S).

10. CHRYSOPHYLLUM ARGENTEUM Jacq. Enum. Pl. Carib. 15. 1760.

C. glabrum Jacq. Enum. Pl. Carib. 15. 1760.
C. caeruleum Jacq. Stirp. Select. Am. 52. ca. 1780.
C. immersum Urb. Rep. Sp. Nov. 15: 414. 1919.

Tree or shrub, sometimes as much as 30 m. tall; leaves elliptic to oblong-elliptic or occasionally ovate, of various sizes up to about 20 cm. long and 8 cm. wide, rounded to acutish or abruptly acuminate at the apex, glabrous above, thinly sericeous at first with whitish hairs beneath, sooner or later glabrate; primary lateral veins well-spaced, usually arcuate toward the margins; secondary lateral veins generally trending about parallel to the primary ones, the long axis of the areolae parallel to the primary veins; flowers clustered in the axils or at recently defoliated nodes, the pedicels mostly 4–13 mm. long; sepals about 1.5–2.5 mm. long, sericeous with fine pale or slightly reddish hairs; corolla about 4–6 mm. long, sericeous to near the base with fine white or somewhat yellowish hairs, the tips and margins of the lobes smooth, the lobes about one-third to one-half as long as the tube; filaments inserted at the level of the sinuses, with more or less evident traces; anthers 0.4–0.8 mm. long; stigma with 5–9 evident to obscure lobes; fruit dark red or purple to blue or nearly black, ellipsoid or occasionally subglobose, mostly 1.5–2 cm. long, occasionally only 1 cm. long, single-seeded; seed-scar basilateral, broad, commonly extending to near the middle.

TYPE: None given; from Martinique, according to Index Kewensis.

Distribution: General throughout the West Indies from Oriente, Cuba, to Trinidad, and in Sucre, Venezuela.

TRINIDAD: *Britton & Britton 2217* (G, NY, US); *Dannouse 8317*, (NY); *Hart 5437* (S); *Sieber 371* (MO). TOBAGO: *Broadway 3991* (A, G, MO, NY, S, US), *4411* (NY, US); *Sandwith 1881* (NY). VENEZUELA: Sucre: *Broadway 495*, near Cristobal Colón (G, K, NY, US); *Broadway 714*, near Cristobal Colón (G, NY, US).

11. CHRYSOPHYLLUM AURATUM Miq. in Mart. Fl. Bras. 7: 97. 1863.

C. sericeum A. DC. Prodr. 8: 158. 1844; not Salisb. 1796.
C. auratum var. *majus* Miq. in Mart. Fl. Bras. 7: 98. 1863.

Shrub or tree sometimes as much as 35 m. tall; leaves elliptic, elliptic-oblong, or elliptic-obovate, about 7–23 cm. long and 3.5–11 cm. wide, rounded or abruptly acuminate at the apex, glabrous above, closely sericeous beneath with a shining sometimes eventually deciduous rufous pubescence that turns pale in age; primary lateral veins mostly well-spaced and arching; secondary lateral veins few, scarcely or not at all visible above, not very prominent beneath; petioles about 6–15 mm. long; flowers clustered in the axils or at recently defoliated nodes, the pedicels about 2–7 mm. long; sepals about 1.2–2.0 mm. long, rufous-strigose, rather firm; corolla tubular, about 3.2–6.5 mm. long, rufous-sericeous outside, at least above, the lobes one-fourth to one-half as long as the tube; ovary appressed-hairy; stigma-lobes mostly 5–6, sometimes as many as 10; fruit purple, ellipsoid, about 1.5–2 cm. long; seed solitary, with broad basilateral obcordate scar extending to about the middle; cotyledons somewhat thickened and a little fleshy, each about as thick as the endosperm.

TYPE: The first specimen cited is *Schomburgk 861*, from "Roraima," British Guiana (F, G, K, NY). *Schomburgk 1389*, from the banks of the Pomeroon River, British Guiana (K), is also cited.

Local names: Sürübüruen, wild star-apple (British Guiana); Maparajuba, rozada brava (Amazonas, Brazil).

Distribution: French Guiana, and northern Amazonas and Para, Brazil, to Colombia, south to Ecuador and Peru.

COLOMBIA: *Mutis 1100* (US), *4030* (F, US), *5831* (US). Bogotá: *Triana s.n.*, près de La Mesa (K). Norte de Santander: *Killip & Smith 20536*, Culaga Valley (G, US). VENEZUELA: *Gollmer s.n.* (G—photo, NY—photo). Merida: *Pittier 12751* (NY, US). Portuguesa: *Pittier 12079*, between Aspini and Aprición (US). Aragua: *Williams 11074* (A, F, US). Sucre: *Broadway 454*, near Cristobal Colón (G, NY, US). BRITISH GUIANA: *Anderson 6*, Aruka River (K); *De La Cruz 3300*, Kabakaburi, Pomeroon District (C, F, G, MO, NY, PA); *De La Cruz 4138*, Kamakusa, upper Mazaruni River, (F, G, MO, NY, PA, US); *Fanshawe 565*, Moraballi Creek (BG); *Fanshawe 2446*, Yarikita Creek, Aruka River (BG); *Hitchcock 17659*, Yaritka and Amakura Rivers (G, NY, S, US); *Hohenkirk 9*, Waini Creek (K); *Sandwith 338*, Essequibo River, near Bartica (K, NY); *Sandwith 678*, Cuyuni River (K); *Schomburgk 550/856* (K), *813* (K), *1507* (K); *Tutin 354*, Cuyuni River (K, US). SURINAM: *B.W. 3327*, Watramiri (K, US), *3873*, Watramiri (K), *4547*, Watramiri (G. K, S, US); *Hostmann 630* (F, K); *Hostmann & Kappler 630B* (S), *1139* (K, MO, S); *Lanjouw 808*, Coppename River, near Raleighfalls (K, Mich, S, US). FRENCH GUIANA: *Gabriel s.n.* (F, G—photo); *Martin s.n.*, Cayenne (K). BRAZIL: *Riedel 1419*, Amazon River (US). Pará: *Ducke 12128*, Rio Branco de Obidos (US); *Ducke 14834*, Obidos (US). Amazonas: *Froes 65*, Esperanza, basin of Rio Solimoes (Herb. Krukoff); *Froes 3232*, Sao Paulo de Olivenca, basin of Rio Solimoes (Herb. Krukoff); *Froes 102*, Esperança, basin of Rio Javary (Herb. Krukoff.) ECUADOR: *Eggers 15450*

(F); *Popenoe 1308*, Portovelo (US); *Popenoe 1349*, Est. Exp. Chobo (US). PERU: San Martin: *Klug 3843*, Juan Jui, Alto Rio Huallaga (F, G, MO, NY, S, US). Loreto: *Williams 3945*, Lower Río Huallaga (F, S, US); *Klug 1318*, near Iquitos (F, US).

12. CHRYSOPHYLLUM PARVULUM Pitt. Contr. Fl. Venez. 42. 1923.

Arborescent shrub or small tree about 4 m. tall, the twigs slender, loosely rufous-strigose when young; leaves elliptic or elliptic-oblong to elliptic-ovate, acute or acuminate, about 4–8 cm. long and 2–4 cm. wide, rufous-strigose beneath when young, the hairs later fading and eventually deciduous; primary lateral veins weak, straight or nearly so, neither crowded nor very distant, not always sharply separable from the larger secondary veins, which trend parallel to them; petioles about 4–9 mm. long; flowers 2–6 in the axils, the pedicels densely rufous-sericeous, about 2 mm. long; sepals about 1.6–2.0 mm. long, rounded, sparsely rufous-strigose; corolla glabrous, 5–6 mm. long, the tube about 2–3 times as long as the rounded lobes; filaments very short, attached at the level of the sinuses; anthers about 0.6–0.7 mm. long; ovary 5-locular, rufous-hairy, tapering above to the conic glabrous style; stigma 5-lobed; fruit ellipsoid, 2.5–3 cm. long, 15–17 mm. thick; seed solitary, about 13–15 mm. long, with a broad obovate scar nearly as long; embryo somewhat thickened, the endosperm relatively thin.

TYPE: *Pittier 9093*, "Selvas do Guaremales, 50 m., cerca de Urama," October 3, 1920 (G, NY, US, V).

Local name: Pascualita.

Distribution: Venezuela and Colombia.

VENEZUELA: *Delgado 212* (US, V). COLOMBIA: *Karsten s.n.*, in 1890 (F—photo & fragment, G—photo, NY—photo).

13. **Chrysophyllum albipilum** Cronquist, sp. nov.

Tree about 7 m. tall; young twigs slender, white-strigose; leaves elliptic or elliptic-obovate, obtuse or acute, about 4–11 cm. long and 2–4.5 cm. wide, white-strigose beneath when young, later glabrate; primary lateral veins about 7–10 pair, straight, or more commonly arcuate near the margins; secondary lateral veins rather irregular, forming a very loose reticulum; petioles about 3–6 mm. long; flowers clustered in the axils, the pedicels gray-sericeous, about 2 mm. long; sepals hairy like the pedicels, the outer acute or acutish, the inner more rounded, about 1.5–1.8 mm. long; corolla green, about 3.7–4.1 mm. long, glabrous, the tube about twice as long as the rounded lobes; filaments short, attached at the level of the sinuses, their traces visible to the base; anthers about 0.5–0.6 mm. long; ovary 4–5-locular, short-hairy, rather abruptly contracted to the thick glabrous 1 mm. style; stigma-lobes 4–5; fruit unknown.

Arbor 7 m. alta, ramulis albo-strigosis glabrescentibus, foliis ellipticis vel elliptico-ovatis, obtusis vel acutis, ca. 4–11 cm. longis 2–4.5 cm. latis, infra albo-strigosis glabdescentibus, venis 7–10-jugis, venuils laxe et irregulariter reticulatis; flores axillares pedicellis 2 mm. longis, sepalis 1.5–1.8 mm. longis griseisericeis, corolla glabra 3.7–4.1 mm. longa lobis ½ tubum aequantibus, filamentis fauce affixis, ovario 4–5-loculare stylo glabro; fructus ignotus.

TYPE: *Klug 4365*, forest, Juan Jui, Alto Rio Huallago, 400–800 m., San Martin, Peru, May, 1936 (US); isotypes at A, F, K.

Distribution: Known only from the type collection, San Martin, Peru.

This species is obviously related to *C. parvulum*, from which it differs in its white, not at all rufous-tinted pubescence, less regular more reticulate leaf-venation, smaller flowers, and disjunct distribution.

14. CHRYSOPHYLLUM ACREANUM A. C. Smith, Brittonia **2**: 161. 1936.

Arborescent shrub or tree up to 12 m. tall, with slender twigs; young twigs, young leaves, petioles, and pedicels conspicuously pubescent with short spreading rufous hairs; leaves elliptic or lance-elliptic, mostly acuminate, about 3–13 cm. long and 1–4 cm. wide, soon glabrous, except along the midrib beneath, where more tardily so; primary lateral veins about 8–18 pair, rather irregularly set, straight, bifurcate near the margins; secondary veins few, trending parallel to the primary ones, and not always sharply separable from them; petioles about 2–3 mm. long; flowers several in axillary clusters, the pedicels about 3–4 mm. long; corolla glabrous, about 3.8–4.4 mm. long, the lobes about one-third to one-half as long as the tube; filaments very short, inserted at the level of the sinuses, or a little above; anthers about 0.4–0.6 mm. long; ovary 5-celled, hairy, with a short glabrous style; stigma-lobes 5; fruit unknown.

TYPE: *Krukoff 5593*, on terra firma, near mouth of Rio Macauhan, basin of Rio Purus, 9 degrees 20 minutes South, 69 degrees West, Acre Territory, Brazil, August 21, 1933 (A, C, MO, NY, US).

Distribution: Acre Territory, Brazil, and adjacent parts of Amazonas.

BRAZIL: Amazonas: *Krukoff 8254*, Sao Paulo de Olivenca, basin of Rio Solimoes (NY).

15. CHRYSOPHYLLUM GRANATENSE Spreng. Syst. **1**: 667. 1825.

Nycterisition argenteum H.B.K. Nov. Gen. & Sp. **3**: 238. t. 244. 1818.

Twigs slender, puberulent; leaves elliptic or elliptic-obovate, about 4–5.5 cm. long and 2–3 cm. wide, rounded to acute, glabrous and shining above, thinly white-sericeous beneath, closely and conspicuously striate above, the veins averaging about 0.5 mm. apart, partly obscured by the pubescence beneath; petioles about 6–8 mm. long; flowers small, about 6–9 in the axils, the pedicels about 3 mm. long; sepals rounded, a little over 1 mm. long, sericeous; corolla glabrous, the lobes evidently longer than the tube, reflexed; filaments attached in the corolla-throat, exserted; anthers glabrous, acute, subcordate at the base; ovary hairy, 5-locular, tapering to the glabrous 1.5 mm. style; stigma-lobes obscure; fruit unknown.

TYPE: *Humboldt & Bonpland*, "prope Jaen de Bracamoras, alt. 620 hex. Regno Novo-Granatense," in the present province of Cajamarca, Peru, in August (NY—photo).

Distribution: Known only from the type collection, Cajamarca, Peru.

I have seen no specimens of this species, but from the type-photo and original description it would seem to be related to the more southern *C. marginatum*, from which it differs in its more closely and conspicuously striate leaves, that are white-sericeous beneath, and in its longer style.

16. **Chrysophyllum dusenii** Cronquist, sp. nov.

Tree, young twigs slender, rufous-sericeous; leaves elliptic, abruptly short-acuminate, about 2.5–7.5 cm. long and 1–2.5 cm. wide, glabrous above, finely, closely, and inconspicuously strigose beneath, much as in *C. inornatum;* primary lateral veins weak, straight or nearly so, ending in a distinct submarginal vein, neither crowded nor very distant, the secondary lateral veins few, trending parallel to the primary ones, and mostly obscure; petioles about 4–5 mm. long; flowers 1–4 in the axils, the pedicels slender, finely and closely hairy, 5–11 mm. long; sepals deltoid-ovate, acute, 1.3–1.5 mm. long, rufous-sericeous; corolla about 3.5–5 mm. long, glabrous, the lobes a little shorter than the tube, but split down 0.4–0.8 mm. farther on the outside, as in *C. panamense;* filaments short, attached at the level of the sinuses; anthers glabrous, about 0.6–0.7 mm. long; ovary short-hairy all over, abruptly contracted to the distinct glabrous 0.5 mm. style, 5-locular, or 6-locular in occasional 6-merous flowers; fruit unknown.

Arbor, ramulis rufo-sericeis, foliis ellipticis abrupte brevi-acuminatis ca. 2.5–7.5 cm. longis 1–2.5 cm. latis, supra glabris, infra tenuiter strigulosis pilis pallidis, venis tenuibus directis, venulis paucis obscuris ad venas parallelibus, petiolis ca. 4–5 mm. longis; flores 1–4 axillares, pedicellis gracilibus 5–11 mm. longis, sepalis rufo-sericeis acutis 1.3–1.8 mm. longis, corolla glabra 3.5–5 mm. longa lobis infra et intus connatis parte libera quam tubo breviore, filamentis fauce affixis, ovario 5–6-loculare stylo glabro 0.5 mm. longo; fructus ignotus.

TYPE: *Dusén 11281,* "Morretes opp. Facenda Marumby, in silva primaeva," April 4. 1914, Paraná, Brazil (S).

Distribution: Rio de Janeiro and Paraná, Brazil.

BRAZIL: Rio de Janeiro: *Glaziou 19596* (K). Sao Paulo or Rio de Janeiro: *Weir 468* (K). Paraná: *Dusén s.n.*, Volta Grande, August 7, 1911 (S); *Dusén 615a*, Volta Grande, July 3, 1914 (S).

17. CHRYSOPHYLLUM MARGINATUM (H. & A.) Radlk. Act. Congr. Bot. Anvers **1885**: 170. 1887.

Large shrub or small tree about 2–10 m. tall; leaves relatively small, about 1.5–10 cm. long and 5–40 mm. wide, narrowly or broadly elliptic to lanceolate, oblanceolate, ovate, or obovate, rounded or even retuse to obtuse of acute at the apex, varying from essentially glabrous to strigose or puberulent along the midrib beneath, or loosely rufous-tomentose on the lower surface; primary lateral veins fairly numerous, parallel and nearly straight, usually impressed above, not much if at all raised beneath, the leaf appearing loosely and weakly striate; secondary lateral veins obscure or sometimes forming an evident reticulum, mostly parallel to the primary ones, and not always sharply distinguishable from them; petioles about 2–8 mm. long; flowers tiny, clustered in the axils or at recently defoliated nodes, subsessile or on pedicels up to 4 mm. long; sepals about 0.5–0.8 mm. long, rounded, rufous-strigose; corolla about 1.7–2.2 mm. long, the lobes 0.9–1.3 mm., often rufous-strigose on the outside; filaments attached at the corolla throat, where a slight thickened ring is more or less evident; anthers about 0.35–0.6 mm. long; ovary shortly rufous-hairy, its faintly lobed style 0.2–0.5 mm. long; fruit black, ellipsoid to subglobose, about 5–10 (rarely 13) mm. long; seed solitary, the scar basilateral, large, retuse, as broad as long, not reaching to the middle of the seed.

TYPE: *Tweedie 11*, *52*, and *53*, from Uruguay, are cited in the original description. An unnumbered *Tweedie* collection is at K.

Local names: Picazó rembiú (Chaco).

Distribution: Uruguay, northern Argentina, and Bolivia to Matto Grosso and Minas Geraes, Brazil.

KEY TO THE VARIETIES OF CHRYSOPHYLLUM MARGINATUM

1. Leaves glabrous at maturity or merely strigose or puberulent along the mibrid beneath.
   2. Corolla more or less appressed-hairy, at least toward the base; pedicels evident, slender. A. var. *marginatum.*
   2. Corolla glabrous, rarely with a few inconspicuous appressed hairs; pedicels generaly very short and stout, the flowers thus closely aggregated. B. var. *obversum.*
1. Leaves more or less persistently tomentose with loose rufous hairs beneath. C. var. *tomentosum.*

17A. CHRYSOPHYLLUM MARGINATUM var. **marginatum** Cronquist, var. nov.

Myrsine marginata H. & A. Journ. Bot. **1**: 283. 1834.

Chrysophyllum marginatum Radlk. Act. Congr. Bot. Anvers. **1885**: 170, sensu stricto. 1887.

C. maytenoides Mart. Herb. Fl. Bras. 177. 1837.

C. myrtifolium Mart. Herb. Fl. Bras. 176. 1837.

C. maytenoides var. *myrtifolium* Miq. in Mart. Fl. Bras. **7**: 100. 1863.

Myrsine grisebachii Hieron. Bol. Acad. Nac. Córdova **4**: 365. 1881.

Chrysophyllum maytenoides α *normale* Kuntze, Rev. Gen. 3^2: 194. 1898.

C. maytenoides β tenue Kuntze, loc. cit.

C. grisebachii Mez, Pflanzenr. **4**: 397. 1902.

C. ilicioides Rusby, Bull. N. Y. Bot. Gard. **4**: 466. 1907.

Flowers borne on evident slender pedicels; base of corolla-lobes and top of tube rufous-strigose, sometimes scantily so; leaves glabrous or merely slightly hairy along the midrib beneath, generally broadest at or below the middle.

Distribution: Range of the species.

BRAZIL: *Riedel 167* (US); *Sello 3528* (G, US); *Sello 4149* (C). Matta Grosso: *Hoehne 4260*, Cuyabá (F), *4692*, Cuyabá (F); *Kuntze s.n.*, July, 1892, Villa Maria (F); *Malme 1843*, Cuyabá (S), *1843a* (S); *Dorrien Smith 12*, Campo Grande, 150 miles southeast of Corumbá (K). Minas Geraes: *Mexia 5844*, Serra do Rio Grande (C, F, G, MO, NA, NY, PA, S, US). Rio de Janeiro: *Glaziou 8226* (K, P, S, US), *12069* (K), *14054* (K). Sao Paulo: *Brade 5755* (S); *Hoehne 39*, Butantan (F); *Mosén 1447* (S); *Usteri 15938*, Pinneiro (F).•Santa Catharina: *Ule 1095* (US). Rio Grande do Sul: *Lindman A1429*, Val de Serra (S); *Lindman A1623*, Porto Alegro (S); *Malme 70* (S, US); *Malme 1461*, near Porto Alegro (S); *Malme 1612* (G, S); *Leite 2548*, Sâo Leopoldo (G); *Sello 1170* (C, PA, S). PARAGUAY: *Balansa 2236* (F, S), *4490* (F); *Fiebrig 5405* (G, K, US), *5949* (US), *6126* (F, G, K, US); *Hassler 437* (K), *564* (K), *3010* (K), *11201* (A, F, K), *11734* (A, G, K, MO, US); *Jorgensen 3760* (A, F, G, MO, NY, PA, S, US); *Kuntze s.n.*, September 1892 (F, NY); *Malme 842* (G, S, US); *Morong 701* (G, Mich, MO, PA, US), *701A* (C, US), *841* (C, G, K, Mich, MO, NY, PA, US); *Rojas 1694* (S). BOLIVIA: La Paz: *Bang 2157*, Coripati, Yungas (NA, NY, PA, US); *Buchtien 4359*, Milluguaya, in Nord-Yungas (US). Santa Cruz: *Herzog 1352* (S); *Kuntze s.n.*, La Cruz (NY). URUGUAY: *Lorentz s.n.*, April, 1876 (G, US). ARGENTINA: Jujuy: *Venturi 5307*, Sierra do Calilegua (G, US). Tucuman: *Burkart 5368*, Sierra de Jan Javier (G); *Jorgensen 1918*, Alpachiri (G); *Lorentz 183*, La Cruz (K); *Lorentz & Hieronymus 1040* (F, US); *Parodi 11088* (F); *Venturi 233* (F, G); *Venturi 844*, Barranca Colorado (A, NY, S, US); *Venturi 6039*, Cumbre de Taficillo (A, US); *Venturi 10349*, Cerro del Campo (MO, S). Chaco: *Jorgensen 2099*, Los Palmas (G, MO, US); *Schulz 886*, Colonia Benitez (NY); *Meyer 728*, Fontana (G). Misiones: *Curran 713*, Puerto Leon (NY); *Grüner 1029*, Loreto (NY); *Rodriguez 350*, Santa Ana (G, NY, US). Corrientes: *Bonpland s.n.* (F); *Parodi 11989*, San Luis del Palmar (G, NY).

17B. CHRYSOPHYLLUM MARGINATUM var. **obversum** (Miq.) Cronquist, comb. nov.

C. ebenaceum Mart. Herb. Fl. Bras. 176. 1837.
C. martianum A. DC. Prodr. 8: 161. 1844.
C. ebenaceum var. *obversum* Miq. in Mart. Fl. Bras. 7: 100. 1863.
C. ebenaceum var. *pedunculatum* Miq. in Mart. loc. cit.
C. ebenaceum var. *latifolium* Miq. in Mart. loc. cit.
C. ebenaceum var. *longifolium* Miq. in Mart. loc. cit.

Flowers mostly subsessile or on very short stout pedicels, thus more or less glomerate; corolla glabrous, or very nearly so; style very short, about 0.2–0.3 mm. long; leaves glabrous or merely slightly hairy along the midrib beneath, often broadest above the middle.

TYPE: *Martius 886*, Saõ Paulo, Brazil (G, MO, NY).

Distribution: Saõ Paulo, Minas Geraes, Matto Grosso, and Rio de Janeiro, Brazil.

BRAZIL: *Burchell 3915* (K), *4681–16* (G), *4705–10* (G), *6988–3* (G, K); *Martius 887* (F, K, NY, PA). Matto Grosso: *Malme 1394*, Cuyabá (G, S, US); *Riedel 847*, Cuyabá (US). Minas Geraes: *Barreto 7307*, Bello Horizonte (F); *Clausen 45* (F, P), *150* (F, NY); *Martius 272* (G—photo); *St. Hillaire 381* (P). Rio de Janeiro: *Glaziou 5930* (F, K, S), *8793* (A, K, NY, S). Saõ Paulo: *Brade 5755*, Moáca (F), *5766* (S); *Hoehne 28793* (cult.) (A, C, F, NY, S); *Loefgren 2940* (F); *Mosen 4659* (S).

17C. CHRYSOPHYLLUM MARGINATUM var. **tomentosum** (Miq.) Cronquist, comb. nov.

C. guilleminianum A. DC. Prodr. 8: 161. 1844.
C. ebenaceum var. *tomentosum* Miq. in Mart. Fl. Bras. 7: 100. 1863.

Leaves more or less persistently tomentose beneath with loose rufous hairs; otherwise much like var. *obversum*, but the leaves less often obverse.

TYPE: Specimens from Minas Geraes by *Widgren* (K, S), and *Pohl* are cited.

Distribution: Minas Geraes, Sao Paulo, and Rio de Janeiro, Brazil.

BRAZIL: *Burchell 4812* (K); *Riedel 8842* (or *2842?*) (NY, US); *Pohl 1461* (F, G. US). Sao Paulo: *Guillemin 499* (F); *Mosén 1447*, Mozy guassu (S), *1449* (S); *Mosén 1448*, Mogy mirim (S), *4659* (S). Minas Geraes: *Brito 19888*, Belo Horizonte (F); *Mosén 1899*, Caldas (S), *1450* (G); *Regnell 855*, Caldas (G, K, S, US). Rio de Janeiro: *Glaziou 12936* (A, K, P).

The name *Chrysophyllum marginatum* (H. & A.) Radlk. is technically a hyponym, and may be considered to be validated here.

Several varieties have been based on differences in size and shape of the leaves, but these features are so variable as to be of very dubious taxonomic value. Except that var. *obversum* more commonly has the leaves broadest above the middle than do the other varieties, it is to be presumed, until careful field study proves the contrary, that variation in size and shape of the leaves of *C. marginatum* is of no taxonomic significance.

18. CHRYSOPHYLLUM OVALE Rusby Mem. N. Y. Bot. Gard. **7**: 320. 1927.

Tree; leaves glabrous, elliptic or elliptic-ovate, conspicuously acuminate, about 3–11 cm. long and 1.5–6 cm. wide; primary lateral veins straight or nearly so, neither crowded nor very distant; larger secondary veins mostly trending parallel to the primaries, and not always sharply separable from them; petioles about 4–12 mm. long; flowers clustered in the axils or at recently defoliated nodes, borne on slender pedicels about 4–6 mm. long, very similar to those of *C. marginatum*, but slightly larger, the corolla about 2.5 mm. long; fruit broadly ellipsoid or subglobose, about 1.5–2 cm. long; seed solitary, with a broad basilateral scar extending about two-thirds its length.

TYPE: *White 1384A*, Esperanza Falls, near the northern tip of Bolivia, 500 feet (NY, US).

Distribution: From Loreto, Peru, to northern Bolivia.

PERU: Loreto: *Klug 2321*, Florida, Río Putumayo, at mouth of Río Zubineta, 180 m. alt. (A, F, US). BRAZIL: *Ule 9694*, Monte Mo, Río Acre, either in Acre Territory or in adjacent Amazonas (K).

19. **Chrysophyllum lucentifolium** Cronquist, sp. nov.

Tree or arborescent shrub; leaves glabrous, shining, elliptic to elliptic-oblanceolate or elliptic-obovate, generally acute or acuminate at the apex, tapering to the base, about 4–10 cm. long and 2–4.5 cm. wide; primary lateral veins prominent, well-spaced, generally arcuate toward the margins; secondary lateral veins conspicuous, irregular, loosely reticulate; petioles about 5–10 mm. long; flowers subsessile, borne single or few together in the axils or at recently defoliated nodes; sepals about 1.2–2.0 mm. long, sparsely strigose, the inner fringed-ciliolate; corolla glabrous, about 2.7–3.0 mm. long, the lobes equaling or much exceeding the tube; filaments attached at or slightly below the level of the sinuses, but their traces raised and conspicuous to the base; anthers 0.9–1.1 mm. long; ovary hairy, 5-lobed, 5-locular; style short and stout, about 0.5 mm. long; stigma-lobes 5; fruit about 1.5–2 cm. long, ovoid or subglobose, somewhat sulcate, at least when dry, between the several seeds; seeds nearly as long as the fruit, each with a linear scar extending its full length.

Arbor vel frutex arborescens, foliis glabris lucidis ellipticis vel elliptico-oblanceolatis vel elliptico-obovatis, apice acuminatis basi cuneatis 4–10 cm. longis 2–4.5 cm. latis, venis prominentibus arcuatis, venulis prominentibus irregulariter reticulatis, petiolis 5–10 mm. longis; flores pauci axillares subsessiles, sepalis 1.2–2.0 mm. longis sparse strigosis, corolla glabra 2.7–3.0 mm. longa, lobis tubum aequantibus vel excedentibus, filamentis fauce affixis, ovario 5-loculare; fructus ovoideus vel subglobosus sulcatus 1.5–2 cm. longus, seminibus paucis cicatrice lineari.

TYPE: *Riedel s.n.*, Macahé, Rio de Janeiro, June 1832 (US).

Distribution: Rio de Janeiro, Brazil.

BRAZIL: Rio de Janeiro: *Riedel 1129*, October, 1832 (NY, US).

This species is probably related to *C. gonocarpum*, from which it differs in its shining, mostly smaller leaves, which are glabrous from the first, shorter corolla and style, and in having the filaments attached near the level of the sinuses, instead of toward the base of the tube.

20. CHRYSOPHYLLUM CAINITO L. Sp. Pl. 192. 1753.

Tree sometimes as much as 30 m. tall; leaves elliptic or oblong, generally abruptly short-acuminate at the apex, up to about 16 cm. long and 8 cm. wide, soon glabrous and shining above, persistently rufous-sericeous or -tomentulose beneath, sometimes becoming a little paler in age; primary lateral veins straight or slightly curved, neither crowded nor very distant, not sharply separable from the larger secondary ones, which trend parallel to them; flowers numerous in axillary clusters, the pedicels closely rufous-hairy, about 5–15 mm. long; sepals about 1.0–1.2 mm. long, closely rufescent, suborbicular; corolla about 3–5 mm. long, the tube glabrous, the lobes rufous-hairy except near the margins, somewhat ovate, more tapering than in most species, equaling or usually a little exceeding the tube; filaments attached a little above the level of the sinuses; anthers about 0.7–0.9 mm. long; ovary 7–12-locular, with a short style and discoid stigma, the stigma-lobes as many as the locules; fruit yellow, green, or purple, large, 3 cm. or more thick, sometimes as much as 12 cm. thick, mostly obovoid or subglobose, several-seeded; seeds flattened, obliquely obovate, with a broad lateral scar extending nearly their whole length.

TYPE: Linnaeus cites no specimens, but refers to several other publications.

Local names: Star-apple; caimito.

Distribution: Colombia to Surinam, north throughout the West Indies, and through Central America to southern Mexico. Widely cultivated and naturalized, so that the original range is uncertain; almost certainly native in the West Indies, and probably also in northern South America, but probably only naturalized on the North American continent.

COLOMBIA: *Mutis 81* (US), *1038* (US). Atlantico: *Elias 992*, Barranquilla (F, US). Bolivar: *Curran 234*, Mompos Island (G, US); *Killip & Smith 14486*, Turbaco (A, G, NY, US). Norte de Santander: *Cuatrecasas, Schultes & Smith 12229*, Sarare region (US). Antioquia: *Daniel 2282*, San Gerónimo (US). Vallé del Cauca: *Triana 2599*, El Espinal, valley of the Magdalena (K, NY, US). Tolima: *Barriga 8408*, Guyabal. VENEZUELA: Merida: *Fendler 2353*, near Tovar (G, K). Aragua: *Chardon 166*, El Rorozal (US). Bolivar: *Rusby & Squires s.n.* (NY). TRINIDAD: *Broadway s.n.*, September 16, 1918 (G, NY, US); *Eggers 45* (US). BRITISH GUIANA: *De La Cruz 2018*, Bartica, Essequibo River (G, MO, NY, US); *Gleason 921*, Rockstone (G, NY, US). SURINAM: *Lanjouw 109*, Charlesburg, near Paramaribo (S); *Pulle 6*, near Paramaribo (US).

21. CHRYSOPHYLLUM COCHLEARIUM LeComte, Notulae Syst. **4**: 63. 1923.

Tree; twigs slender, rufous-tomentose when young; leaves obovate or elliptic-obovate, about 4.5–7.5 cm. long and 2–4 cm. wide, closely sericeous with fine rich red hairs on both sides when young, soon glabrate above, and probably eventually so beneath; primary lateral veins about 8–12 pair, arcuate; secondary lateral veins obscure, loosely reticulate, the stronger ones mostly trending nearly at right angles to the primary veins; petioles about 1 cm. long; flowers in small clusters at defoliated nodes, the pedicels rufous-sericeous, about 1–2 mm. long; sepals hairy like the pedicels, about 1.5 mm. long; corolla about 3.0–3.5 mm. long, the lobes rufous-sericeous on the back, twice as long as the tube, or longer; filaments attached at the level of the sinuses, or a little above, slender, about 1 mm. long; ovary closely rufous-hairy, 5–6-locular; style glabrous, about 0.7–1.1 mm. long; stigma-lobes obscure; fruit unknown.

TYPE: *Benoist 224*, French Guiana (F—fragment).
Local name: Bois cuiller.
Distribution: Known only from the type collection, French Guiana.

22. CHRYSOPHYLLUM RUFUM Mart. Herb. Fl. Bras. 174. 1837.

C. rufum var. *acutifolium* Mart. Herb. Fl. Bras. 289. 1837.
C. tomentosum Freire-Allem. Trab. Comm. Sci. Expl. Bot. Rio de Janeiro 1: 69. 1866.

Small, much-branched tree about 5–15 m. tall; leaves elliptic or elliptic-lanceolate, usually acuminate, about 3.5–8 cm. long and 1.5–2.5 cm. wide, glabrous and shining above, sericeous-tomentose beneath with dull rufous hairs; primary lateral veins about 6–15 pair, fewer, more widely spaced, straighter, and more conspicuously bifurcate near the margins than in *C. pavonii;* secondary lateral veins trending parallel to the primary ones, the larger ones not always separable from them; petioles about 5–9 mm. long; flowers 6–7-merous throughout, clustered in the axils and at defoliated nodes as well, the pedicels slender, rufous-sericeous, about 3 mm. long; sepals hairy like the pedicels, about 1 mm. long; corolla sparsely rufous-hairy or glabrous, about 2.4–2.6 mm. long, the lobes twice as long as the tube, each bearing three thickened nerves within; filaments attached at the level of the sinuses, slender, flexuous or variously bent, the traces visible to the base; anthers cuspidate, about 0.8 mm. long, dehiscent to the base, but the walls remaining closely approximate along the line of dehiscence, except at the top, where they spread to form an evident apical pore; ovary short-hairy, 6–7-locular; style slender, about 0.8 mm. long; stigma-lobes obscure; fruit smooth, about 8–12 mm. long, or perhaps sometimes larger, 1–2-seeded, sub-pyriform; seeds obovoid, obtuse at the apex, acute at the base, the seed-coat regularly tuberculate, sulcate between the tubercles; seed-scar basilateral, suborbicular, extending about to the middle of the seed.
TYPE: *Martius 272*, in sylvis, Caa-tinga, Bahia, Brazil (G—photo).
Distribution: Bahia, Cara, and Rio de Janeiro, Brazil.

BRAZIL: Ceara: *Ule 9079*, Serra de Baturite (C, F, K). Bahia: *Martius 521*, Cruz de Casma (F, G, K, MO, NY); *Tuschnath 25* (F). Rio de Janeiro: *Glaziou 11146* (K).

The description of the fruit and seed for this species is taken from that given by Miquel in the Flora Brasiliensis.

23. **Chrysophyllum pavonii** Cronquist, nom. nov.

Nyctcrisition ferrugineum R. & P. Fl. Per. 2: 47. *pl. 187*. 1794.
Chrysiphyllum ferrugineum Steud. Nom. ed. 2. 1: 359. 1840, not Gaertn. f. 1805.

Tree with hard fulvous wood; latex turning blood-red when exposed to air; leaves somewhat astringent, elliptic-oblong, rounded to more commonly acute or acuminate, about 4–13 cm. long and 2–5 cm. wide, glabrous above, sericeous-tomentose beneath with lustrous deep-rufous hairs; primary lateral veins straight or slightly curved, bifurcate near the margins, about 12–25 pair, not always sharply separable from the larger secondary ones, which trend parallel to them; petioles about 1 cm. long; flowers clustered in the axils or at recently defoliated nodes, the pedicels rufous-sericeous, about 2 mm. long; sepals rufous-hairy like the pedicels, rounded, 1.1–1.3 mm. long; corolla about 3.0–3.5 mm. long, the lobes scarcely equaling the tube, the lobes and the upper part of the tube sericeous-strigose with rufous hairs;

filaments attached at the level of the sinuses, short and stout; anthers about 0.5–0.6 mm. long; stigma-lobes obscure; fruit unknown.

TYPE: One of two or more collections from Peru by *Ruiz & Pavon*. Specimens from apparently two different collections of this group are at F; two photographs are at G, and one at NY.

Local name: Chichimicuna.

Distribution: Known only from the original collections, Peru.

24. CHRYSOPHYLLUM JANUARIENSE Eichl. Vidensk. Meddel. **1870**: 206. 1871.

Twigs densely villous-tomentose with spreading rufous hairs; leaves elliptic-oblong, rounded to subcordate at the base, acute at the apex, about 7–13 cm. long and 3–6 cm. wide, soon glabrate and shining above, persistently hairy beneath with long-stalked two-forked rufous hairs, more densely so along the midrib; primary lateral veins about 9–14 pair, irregularly spaced, straight, bifurcate near the margins; secondary lateral veins loosely and irregularly reticulate, some of the larger ones sometimes parallel to the primary ones; petioles about 4–5 mm. long; flowers clustered in the axils, the pedicels densely spreading-hairy like the twigs and petioles; sepals short, broad, and rounded, hairy like the petioles; corolla glabrous, the lobes about equaling the tube; filaments inserted near the middle of the tube, slender, half as long as the cordate laterally villous anthers; ovary depressed-globose, densely rufous-hairy, 5-locular; style short, glabrous; stigma-lobes obscure; fruit unknown.

TYPE: Two collections by *Glaziou* from Rio de Janeiro were cited by Eichler. The first number, *1055*, is of plants past anthesis, without corollas (G, K, NY, P). Duplicates of the second number, *2598*, have flowers in maturing bud, the corollas ready to open (A, K). This number is accordingly selected as the type.

Distribution: Rio de Janeiro and perhaps elsewhere in Brazil.

BRAZIL: *Pearce s.n.*, Santa Ana, 3–4,000 feet, 1866 (K).

The Paris specimen cited above has the number 1055 marked out, and replaced with *8231*. There is also a collection at Kew bearing the numbers *8231 = 1005*.

25. CHRYSOPHYLLUM SPARSIFLORUM Klotzsch ex Miq. in Mart. Fl. Bras. **7**: 90. 1863.

C. sparsiflorum var. *fagifolium* Miq. in Mart. loc. cit.

Young twigs rufous-sericeous; leaves lance-elliptic to elliptic or elliptic-ovate, about 5–12 cm. long and 2–4.5 cm. wide, yellowish-sericeous on both sides when young, soon glabrate above, more tardily so beneath, the hairs loosely appressed, about 0.3–0.6 mm. long; primary lateral veins arcuate or unequally bifurcate near the margin, irregularly set, the secondaries mostly trending about parallel to them and not always sharply separable; petioles about 3–6 mm. long; pedicels about 1–4 in the axils, sericeous, 2–3 mm. long, deflexed or recurved at least before anthesis; sepals hairy like the pedicels, about 1.6–1.8 mm. long; corolla glabrous, about 3.5 mm. long, the lobes a little longer than the tube; filaments slender, shorter than the anthers, nearly or quite free from the tube; anthers cordate-ovate, minutely apiculate, about

1.5 mm. long, densely woolly-villous on the margins; ovary hairy, 5-locular, the style short, glabrous; stigma-lobes obscure; immature fruit glabrous, obovoid or subglobose, over 1 cm. long, single-seeded.

TYPE: *Schomburgk 680*, British Guiana (F—fragment, K).

Distribution: British Guiana, and Para, Brazil; certainly to be expected in northern Amazonas, Brazil.

BRITISH GUIANA: *Schomburgk 420*, Pirara (F). The Kew specimen cited above bears both numbers, *680* and *420*.

The description of the fruit is taken from Miquel's description, which is based on a specimen collected by Spruce near Santarem, Para, the type of var. *fagifolium*. A photograph of a plant in the Munich herbarium, labeled *Chrysophyllum sparsiflorum* var. *fagifolium*, agrees with this description, and may represent an isotype of the variety.

26. CHRYSOPHYLLUM PULCHERRIMUM Mart. & Eichl. ex Miq. in Mart. Fl. Bras. **7**: 92. 1863.

Tree up to 10 m. tall; young twigs rufous-sericeous; leaves elliptic or elliptic-ovate, rounded to acutish at the apex, about 4–11 cm. long and 2.5–5.5 cm. wide, glabrous above, persistently sericeous beneath with rich purplish-red hairs; venation of the usual chrysophylloid type, with straight bifurcate irregularly set primary lateral veins, and relatively few secondaries, these mostly parallel to the primaries; petioles about 1 cm. long; flowers several in axillary clusters, the pedicels slender and lax, rufous-sericeous, about 15–25 mm. long; sepals rufous-sericeous, about 2.5–3 mm. long; corolla a little longer than the calyx, nearly glabrous, the lobes shorter than or about equaling the tube; filaments slender, inserted about at the middle of the tube; anthers cordate-ovate, emarginate at both ends, long-villous; ovary rufous-sericeous, tapering to the glabrous 1 mm. style; fruit unknown.

TYPE: *Sello 1036*, eastern Brazil (C, F—photo and fragment, G—photo, K, NY—photo). Another collection from eastern Brazil, by Freireiss, is also cited in the original description.

Distribution: Known only from the original collections, in eastern Brazil. A specimen at K, without designation of the collector, bears the data, "Camamée, Prov. do Bahia." It is very probably an isotype.

27. CHRYSOPHYLLUM SPLENDENS Spreng. Syst. Veg. **1**: 666. 1825.

C. amplifolium A. DC. Prodr. **8**: 159. 1844.

Tree about 10 m. tall; young twigs closely rufous-sericeous; leaves elliptic-oblong to broadly elliptic-oblanceolate, about 10–30 cm. long and 4–12 cm. wide, rounded to abruptly short-acuminate or merely acutish at the apex, glabrous above, densely and persistently sericeous beneath with coppery-rufous hairs; primary lateral veins about 10–22 pair, rather irregularly set, mostly arcuate near the margins; secondary lateral veins few, the larger ones mostly trending parallel to the primaries; petioles about 8–17 mm. long; flowers clustered in the axils, the pedicels rufous-sericeous, about 7–13 mm. long; sepals hairy like the pedicels, about 2.0–2.8 mm. long; corolla about 3.5 mm. long, moderately rufous-strigose or rufous-sericeous below, the hairs concentrated near the sinuses; corolla-lobes from a little shorter to a little longer than the tube; filaments short, attached about at the middle of the tube; anthers about 0.9–1.1 mm. long, villous, sometimes sparsely and shortly so; ovary sulcate, closely hairy, 5-locular, tapering to the 1.5 mm. style, which is glabrous above; stigma-lobes 5; fruit unknown.

TYPE: None given; possibly one of the *Sello* collections cited below.

Distribution: Bahia and perhaps elsewhere in eastern Brazil.

BRAZIL: *Sello 375* (G—photo), *798* (K). Bahia: *Riedel 8*, near Ilheos (NY, US); *Froes 1077*, road to Pontal, basin of Rio Santa Ana (A); *Blanchet 3202A* (G—photo, NY—photo).

28. CHRYSOPHYLLUM ARENARIUM Freire-Allem. Trab. Comm. Sci. Expl. Bot. Rio de Janeiro **1**: 72. *pl. 22.* 1866.

Much-branched shrub or small tree sometimes 7 m. tall; twigs roughened by the numerous lenticels, loosely rufous-sericeous when young, soon glabrate; leaves ovate or elliptic, acutish or bluntly acuminate, about 1.5–6 cm. long and 1–4 cm. wide, sericeous-tomentose with more or less rufous hairs when unfolding, very soon glabrate on both sides, or sometimes with some persistent hairs along the midrib beneath; primary lateral veins straight, impressed above, not much raised beneath, about 1.5–4 mm. apart; secondary lateral veins obscure; petioles about 3–4 mm. long; sepals more or less rufous-strigose, about 0.8–0.9 mm. long; corolla glabrous, about 2.0 mm. long, the lobes equaling or much exceeding the tube; filaments short, attached near the middle of the tube; anthers long-villous on the margins, cordate-ovate, retuse or obscurely apiculate at the summit, about 1.0 mm. long; ovary short-hairy, 5-locular; style glabrous, scarcely 0.5 mm. long; stigma-lobes obscure; fruit obovoid, about 12–13 mm. long and 8–9 mm. thick, subtruncate at the apex, with thin pulp; seed solitary, obovoid, with broad basilateral scar extending about two-thirds of the way to the summit.

TYPE: *Freire-Allemao s.n.*, "Habitat in arenosis circa civitatem Fortaleza dictam, in provincia Ceara, April."

Distribution: Ceara to Rio de Janeiro, Brazil.

BRAZIL: Ceara: *Luetzelburg 26445*, Araras Carasco, Serra do Araripe (F). Rio de Janeiro: *Glaziou 11147* (K), *11148* (K).

29. CHRYSOPHYLLUM INORNATUM Mart. Herb. Fl. Bras. 176. 1837.

C. lanceolatum Casar. Stirp. Bras. Dec. 7: 64. 1843; acc. to Miq.

Twigs slender, yellowish-sericeous when young; leaves lance-elliptic, acuminate, about 4–10 cm. long and 12–28 mm. wide, glabrous above, finely strigose or sericeous-strigose beneath with closely appressed whitish hairs about 0.1–0.3 mm. long, sooner or later glabrate; primary lateral veins mostly straight or nearly so and bifurcate near the margins, not sharply separable from the secondary ones, which trend parallel to them, the lateral veins thus appearing rather crowded, about 1–3 mm. apart; petioles about 2–7 mm. long; flowers solitary or few in the axils, the pedicels slender, sericeous, about 5–8 mm. long; sepals about 2 mm. long or less, ovate, subacute; corolla about 3.0 mm. long, glabrous, the lobes about equaling the tube; filaments short, attached near the base of the tube; anthers apiculate, cordate at the base, villous; ovary hairy, 5-locular; style short, glabrous; stigma obscurely 5-lobed; fruit unknown.

TYPE: *Sello 4530,* toward Austrum, Rio Grande do Sul (C, F—photo and fragment, G—photo, K, NY—photo, US).

Distribution: Rio Grande do Sul to Rio de Janeiro, Brazil.

30. CHRYSOPHYLLUM FLEXUOSUM Mart. Herb. Fl. Bras. 98. 1837.

C. elegans Raunk. Vidensk. Meddel. **1889:** 9. 1889.

Small tree up to about 12 m. high; leaves elliptic or elliptic-oblong, mostly acute or more commonly acuminate, about 6–40 cm. long and 2–12 cm. wide, glabrous above, sericeous-strigose with whitish hairs beenath, the hairs about 0.3–0.6 mm. long, sooner or later glabrate; primary lateral veins well-spaced, about 5–15 mm. apart, mostly arcuate near the margins; secondary veins not very prominent, generally forming a loose open reticulum; petioles about 8–20 mm. long; flowers borne in the axils or at recently defoliated nodes, about 2–13 in a cluster, the pedicels about 6–16 mm. long; sepals about 1.5–3.5 mm. long, appressed-hairy; corolla about 3.7–7.0 mm. long, glabrous or nearly so, the lobes a little shorter than the tube; filaments attached at or a little below the middle of the corolla-tube, longer than the anthers; anthers villous, pointed, about 1.0–1.4 mm. long; ovary appressed-hairy, narrow, tapering gradually to the stout glabrous style about 1.2–2.5 mm. long; fruit unknown.

TYPE: *Martius 102,* in acumine montis Corcovado, Brazil, 1838 (F, G, K, MO, NY, PA, US).

Distribution: Minas Geraes, Rio de Janeiro, and Sao Paulo, Brazil.

BRAZIL: *Burchell 1800* (G, K); *Glaziou 793* (US); *Pohl 997* (K); *Riedel 15* (US), *1290* (US); *Sello 1682–836* (C). Minas Geraes: *Mexia 5427,* Viçosa (C, F, G, MO, NY, PA, S, US). Rio de Janeiro: *Brade 42* (G); *Glaziou 193* (K), *1355* (NY), *9501* (K), *11582* (A, C—photo, K, P, S), *17124* (A, K, NY); *Guillemin 250,* Mont du Corcovado (F, P); *Hoehne 24880,* Tijuca (F); *Riedel 565,* Macahé (NY, US); *Riedel 1223* (NY, US); *Riedel 3012,* Corcovado (US). Sao Paulo: *Mosén 2896,* Santos (K, S); *Mosén 3428,* Santos (S).

DOUBTFUL AND EXCLUDED SPECIES

Chrysophyllum alnifolium Engl. Bot. Jahrb. **12:** 522. 1890. = *Pouteria engleri* Eyma.

C. ambelaniifolium Sandw. Kew Bull. **1931:** 476 = **Oxythece ambelaniifolia** (Sandw.) Cronquist, comb. nov.

C. aquaticum H.B.K. Nov. Gen. & Sp. **3:** 236. 1818. Nom. dub. based on sterile specimens.

C. brasiliense A. DC. Prodr. **8:** 156. 1844. = *Sarcaulus brasiliensis* (A. DC.) Eyma.

C. bumelioides Mart. Herb. Fl. Bras. 177. 1837. = *Pradosia lactescens* (Vell.) Kuhlm.

C. buranhem attr. to Riedel by Hook. & Jacks. Kew Ind., as a synonym. Buranhem was merely listed by Riedel as the vernacular name of an unidentified species of "*Chrysophyllum.*" The plant is a *Pradosia.*

C. cayennense A. DC. Prodr. **8:** 160. 1844. = *Pouteria cayennensis* (A. DC.) Eyma.

C. crotonoides Klotzsch ex Hook. & Jackson, Ind. Kew. Suppl. **1.** = *Pouteria crotonoides* (Pierre) Baehni.

C. eximium Ducke, Bull. Mus. Hist. Nat. Paris II. **4:** 744. 1932. = **Ecclinusa eximia** (Ducke) Cronquist, comb. nov.

C. cuspidatum Hoehne, Ostenia 302. 1933. An undescribed new genus.

C. gardneri Mart. & Miq. in Mart. Fl. Bras. **7:** 102. 1863. = *Pouteria gardneri* (Mart. & Miq.) Baehni.

C. glaucescens Engl. Bot. Jahrb. **12:** 521. 1890. = **Oxythece glaucescens** (Engl.) Cronquist, comb. nov.

C. glycyphloeum Casar. Stirp. Bras. Dec. **1:** 12. 1842. = *Pradosia glycyphloea* (Casar.) Kuhlm.

C. humboldtianum Roem. & Schult. Syst. **4:** 813. 1819. Nom. dub.

C. inophyllum Mart. ex Miq. in Mart. Fl. Bras. **7:** 105. 1863. = *Pradosia inophylla* (Mart.) Ducke.

C. klugii Baehni, Candollea **7:** 134. 1936. = **Ecclinusa klugii** (Baehni) Cronquist, comb. nov.

C. leptocarpum Spruce ex Baehni, Candollea **9:** 427. 1942. = *Oxythece leptocarpa* Miq. in Mart. Fl. Bras. **7:** 106. 1863.

C. longifolium Mart. & Eichl. ex Miq. in Mart. Fl. Bras. **7:** 97. 1863. Insufficiently known; certainly none of the otherwise known species of *Chrysophyllum*. Perhaps a *Pouteria*.

C. macoucou Aubl. Pl. Gui. **1:** 233. *pl. 92.* 1775. Nomen confusum, based on fruit of *Chrysophyllum cainito* and foliage of some other plant.

C. macrophyllum Lam. Tab. Encyc. **2:** 44. 1793. = *Pouteria macrophylla* (Lam.) Eyma.

C. macrophyllum Mart. Herb. Fl. Bras. 175. 1837. = *Sarcaulus brasiliensis* (A. DC.) Eyma.

C. manglillo Lam. Tab. Encyc. Tab. Encyc. **2:** 45. 1793. = *Myrsine manglilla* (Lam.) R. Br.

C. melinoni Engl. Bot. Jahrb. **12:** 521. 1890. = *Micropholis guyanensis* (A. DC.) Pierre.

C. michino H.B.K. Nov. Gen. & Sp. **3:** 236. 1818. Nom. dub.; perhaps a species of *Manilkara*.

C. minutiflorum Britt. Bull. Torrey Club **48:** 337. 1922. = *Pouteria minutiflora* (Britt.) Sandw.

C. oleaefolium Spruce ex Miq. in Mart. Fl. Bras. **7:** 101. 1863. = *Oxythece* sp.

C. oppositum Ducke. Trop. Woods **71:** 18. 1942. = **Ecclinusa opposita** (Ducke) Cronquist. comb. nov.

C. parviflorum Casar. Stirp. Bras. Dec. **7:** 63. 1843. Nom. dub.; possibly not sapotaceous.

C. pumilum Chod. & Hass. Bull. Herb. Boiss. II. **7:** 674. 1907. = **Ecclinusa pumila** (Chod. & Hass.) Cronquist, comb. nov.

C. pumilum f. glabrescens Chod. & Hass. loc. cit. = praec.

C. pyriforme Willd. Sp. Pl. **1:** 1084. 1797. A substitute name for *C. macoucou*, q.v., supra.

C. ramiflorum (Mart.) A. DC. Prodr. **8:** 158. 1844. = *Ecclinusa ramiflora* Mart.

C. reticulatum Engl. Bot. Jahrb. **12:** 522. 1890. = *Pouteria reticulata* (Engl.) Eyma.

C. rufocupreum Ducke, Arch. Inst. Biol. Veg. Rio de Janeiro **2:** 67. 1935. = **Ecclinusa rufocuprea** (Ducke) Cronquist, comb. nov.

C. sessiliflorum Poir. Encyc. Suppl. **2:** 16. 1811. Nom. dub.

C. schomburgkianum A. DC. Prodr. **8:** 157. 1844. = **Pradosia schomburgkiana** (A. DC.) Cronquist, comb. nov.

C. ulei Krause, Notizbl. Bot. Gart. Berl. **6:** 171. 1914. = **Ecclinusa ulei** (Krause) Gilly in herb.

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THE CASE OF THE VANISHING FICUS RACEMOSA

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Is it possible that *Ficus racemosa,* a well-described and clearly illustrated species, disappeared after it had been reported more than 30 times and had been said to be cultivated in several botanical gardens? Why, 125 years after its ancestral history began, did reports of it become progressively less definite? Why was the authorship of the name *racemosa* often ascribed to other writers and texts than to Linnaeus, Sp. Pl. ed. 1? What, if any, is the relationship between *F. racemosa L.* and *F. glomerata* Roxb.? What is the synonymy of the species?

HISTORY AND CHARACTERS OF FICUS RACEMOSA

The development of knowledge of characters of *F. racemosa* reverses the usual process, since the first description of the tree is the best. Later characterizations added few valuable facts and some incorrect statements. This deterioration of information must be recorded here, since it played a part in the disappearance of *F. racemosa.*

Almost all writers on this species agree with Linnaeus' choice of *Atty-alu* Rheede as the prototype of *F. racemosa.* This tree was described in detail and well illustrated by Rheede (1678) under the name of *Atty-alu* in the text, *Atti-alu* on the plate. The text says that it grows in sandy places (in Malabar, India) and is a tall tree with a very thick trunk, thick roots spreading above and beneath the ground, long branches with dense foliage, and a very milky latex which reddens on exposure to the air. No mention is made of aërial roots, although the ground roots are said to have fibrous lateral rootlets. The petioles are stout. The blades are described as "oblong-round," twice as long as wide, gradually narrowed to an apical cusp, rounded at the petiole, soft, bare, smooth, shining green on the upper surface and bright beneath, with veins arched near the margin and reflexed, and with many transverse veins. Figure 1 B shows a typical leaf of "*Atti-alu*" in which some significant characters not included in the text are the long basal veins, the rather few secondary lateral veins, the lack of an inframarginal vein, and the indistinct, barely suggested veinlets.

The figs of *Atty-alu* are "like our figs" (*F. carica*) in part. Many receptacles are clustered in the same mass, according to the text. The plate shows them in a leafless simple raceme growing from a lower branch which bears one leaf near the trunk. Some figs are almost globose and others turbinate. The broad apex is a little depressed around the closed mouth, and the base is slightly narrowed to a peduncle about 1 cm. long and 2–3 mm. thick. The height and greatest width of the receptacles measure about 3 cm. The surface is said to be more or less hairy, and to turn from green to red. No basal bracts are pictured. Fruits inside the receptacle are mentioned as "grains," and illustrated, too indefinitely, in a longitudinal drawing of the inside of the fig. No data on flowers are given. It is stated that the tree bears edible fruit two or three times a year, and that its roots and figs have medicinal value.

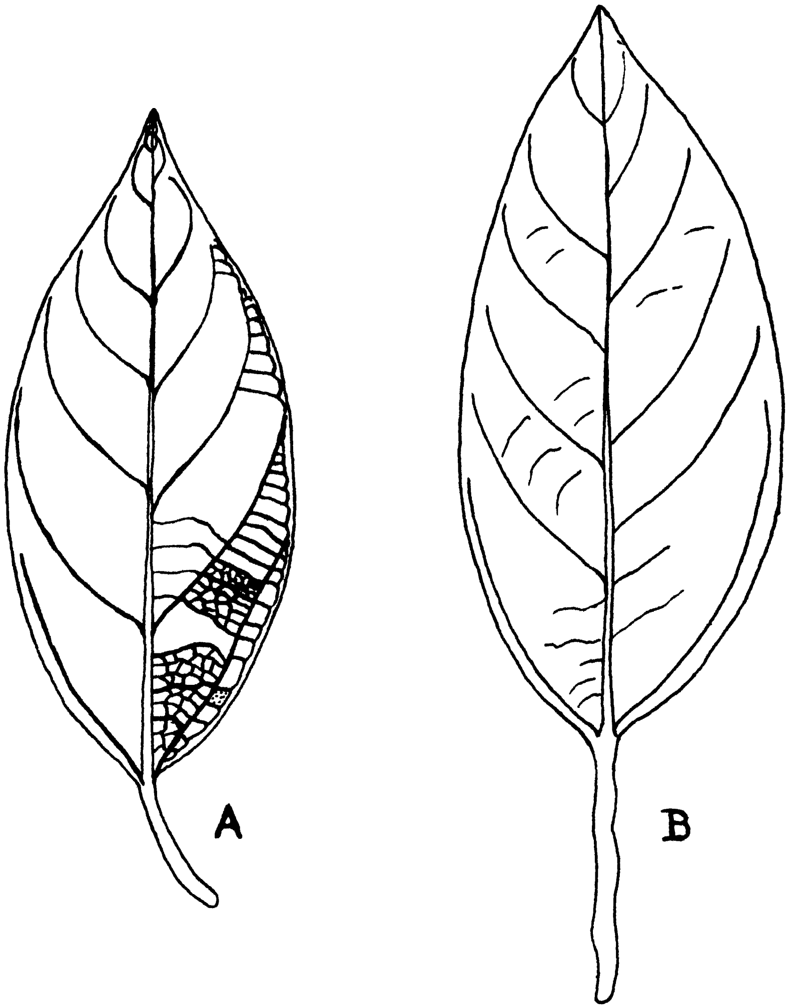

FIG. 1. A, under surface of a leaf from a living tree labeled *Ficus glomerata;* Miami, Florida. The left half shows the appearance of the veins in a fresh leaf; the right half indicates the veining apparent in a dry specimen. B, copy of a leaf of *Atty-alu* (*Atti-alu*) Rheede, Hort. Mal. 1: *pl.* 25. × 0.75.

At the end of Rheede's text Syen, an editor, added a Latin name: ***Ficus*** *malabarensis folio oblongo, acuminato, fructu vulgari aemulo.* Syen's polynomial was used by Ray (1688), with due credit to its author, as the title of the species; but later references to this name were connected with Ray rather than Syen.

Linnaeus first mentioned the species in 1749 under the title *Ficus foliis ovatis acutis integerrimis, caule arboreo, fructu racemoso;* and referred to *Atty-alu* Rheede and to Ray. Thus he modified and added to the leaf characters and emphasized the type of fruit cluster. Here it should be noted that *racemus* originally meant simply a cluster and usually was exemplified by a cluster of grapes. Rheede did not use the word, but illustrated what is almost the modern idea of a raceme. Linnaeus may have had the present conception of that term; but some later writers evidently visualized bunches of receptacles when they used it.

In 1753 Linnaeus included *F. racemosa* among the seven species of *Ficus* in the first edition of *Species plantarum,* using his polynomial of 1749 as description and citing Rheede and Ray. Here and in the next two editions of the book the name given by Rheede is spelled *Alty-alu.* From this time through 1820 most writers on *F. racemosa* listed *Atty-alu* as a synonym, and almost all, except those editing or commenting on Rheede's text, misspelled the name as Linnaeus's printer had done, thus indirectly confessing that they were unfamiliar with its source. In 1822 Hamilton called attention to the incorrect orthography, but allocated *Atty-alu* to *F. glomerata.* Most later writers followed Hamilton's correction, although not his synonymy.

In the second and third editions of *Species plantarum* Linnaeus added *Grossularia domestica* Rumph. as a synonym of *F. racemosa.* This species has not been definitely identified, but Merrill (1917) has thought that it is *F. trematocarpa* Miq. or *F. descaineana* Miq. The very poor plates illustrating it show an excavated trunk such as is made by epiphytic roots, aërial roots from the branches, leaves like those of *Atty-alu,* but without distinct basal veins, and axillary figs on leafy twigs: all characters not found in *F. racemosa.* But *Grossularia domestica* continued to be cited under that species and may be the reason why the second rather than the first edition of *Species plantarum* often has been stated as the source of *F. racemosa.*

Editions 12 and 13 (1767, 1770) of Linnaeus's *Systema naturae* contained the additional and significant statement that the tree had impressed-punctate leaves sprinkled with white points. The characterization in these books was used also in editions 13, 14, and 15 (1774, 1784, and 1797, 1798) of *Systema vegetabilium* and was quoted by several later writers. However, Gmelin's revised 13th edition (1791) of *Systema naturae,* and Turton's English edition (1806) of Gmelin's work described the tree as having erect branches, elliptical-oblong leaves which were glabrous, and pale on the under surface, and pedunculate receptacles: characters evidently drawn from Thunberg (1786, see below).

Up to 1806 very few reports since Rheede's showed evidence of actual observation of *F. racemosa*, or indicated locations other than India or the East Indies. But Philip Miller, who later was said to have cultivated it in England in 1759, spoke of it in his *Gardener's dictionary* of that date under the polynomial given by Linnaeus in 1749, saying that it was a tree 25 ft. high, with many branches, oval-pointed, "lucid" green, smooth leaves, and small inedible "fruits" in clusters from the sides of the branches. In the 1768 edition of his work he inserted the word *Racemosa* after *Ficus* in the title. Aiton (1789) included *F. racemosa* in his book on Kew Gardens and referred to Miller (1759). Aiton drew his description of this actual plant from Linnaeus (1784), and called it the Red-wooded Fig Tree. Martyn's edition (1807) of Miller's text shows less evidence of first-hand acquaintance, for he quotes Thunberg (1786) almost word for word, with the addition of "points" from Linnaeus (1784). The second edition of Aiton's work (1813) changed the previous description of *F. racemosa* to one made by Willdenow (1806), and called the tree the Cluster Fig. Thunberg (1786) compiled, at some length, descriptions apparently taken from eye-witnesses. He added to the characters listed above under Gmelin the statements that the branches were ferruginous, the twigs scattered and short, the leaves 2.5–7.5 cm. or more in length, on petioles 2.5 and 5 cm. long, and the figs the size of a plum. Neither he nor Miller mentioned "points."

Lamarck (1788) made a detailed, but confusing summary of the species, first quoting the Linnean description in the *Systema* and his references, including "*Atty-alu*," and then characterizing var. β as having narrow lanceolate leaves. He cited two references for the variety, which he said was the *Atti* of the Indians. Neither reference belongs to this plant, if it is related to *F. racemosa*. Finally Lamarck described what apparently was intended for the type, but, as Hamilton (1822) pointed out, resembled *Grossularia domestica*. Although he added that young trees grew in the (French) Royal Gardens his identification seems doubtful.

Vahl (1806) described *F. racemosa* as having hairy twigs and petioles, small substriately veined leaves, and sessile figs. Although his plant seemed to differ from the type of *F. racemosa* his characterization was quoted by Roemer and Schultes (1817) in their edition of the *Systema*. Link (1822), writing of the Berlin Royal Gardens, cited Vahl as the author of *F. racemosa*. Link may have referred to a tree mentioned by Willdenow (1809) as growing in that place. Perhaps this was the plant which Kunth (1846, 1847) called *F. racemosa* (Vahl) Willd. and said was a doubtful species, since Kunth referred to Link.

Willdenow's edition (1806) of *Species plantarum* was the first important work to include both *F. racemosa* and *F. glomerata* Roxb. (1798). The description of the former is a mixture of characters seemingly drawn from various predecessors; including oblong-lanceolate leaf-blades (rather like those of Lamarck's variety) and green dots (like those of Roxburgh) which he omits from his summary of Roxburgh's species. He referred to *"Alty-alu,"* and differentiated *F. racemosa,* the "grape-bearing fig," from *F. glomerata,* the "fasciculate fig," by its smaller leaves as well as its racemes. Otherwise few differences were stated. Willdenow was referred to by most later writers on *F. racemosa* and was listed as the author of that name by Persoon (1807) and Graham (1839, p. 191). Graham there reported *F. racemosa* from the Konkans in western India, but merely referred to *"Alty-alou"* and *Grossularia domestica.* On p. 190 he asked whether *F. racemosa* Willd. and *"Atti-alou"* were synonyms of *F. glomerata* Roxb., which he described apparently from life, and which also grew in the Konkans. It seems likely that both *F. racemosa* and *F. glomerata* of Willdenow were the species known as *F. glomerata* Roxb.

After 1806 reports of *F. racemosa* as an independent species were brief, partly incorrect, or suggestive of doubt as to the tree's status. About the middle of the nineteenth century the name ceased to appear except rarely and as a doubtful synonym.

HISTORY OF FICUS GLOMERATA

Roxburgh (1798) described this species from the Coromandel Coast of southeastern India. The characterization is detailed and the accompanying illustration is in color.

During the next thirty years only a few writers mentioned *F. glomerata.* Almost all of these except Hamilton (1822) were compilers who derived their information from Roxburgh and so added nothing to his work. Willdenow (1896) probably was the first to include the species, for he was credited by the editors of Roxburgh (1832) with the authorship of the name, although his description referred to Roxburgh. Willdenow is listed in several other texts as the author, but Roxburgh is cited by most writers.

After 1830 reports of *F. glomerata* increased in number and spread of distribution, and have continued to the present time. Illustrations were made by Wight (1843), Brandis (1874), and others. Specimens from Roxburgh's and from another collection were included under the name of *F. glomerata,* No. 4511 (incorrectly printed 4501) A and B, in Wallich's catalogue (1831). These have been declared correctly allocated by King and others. More recent specimens may be found in many herbaria, and living trees have been cultivated in places far removed from their original homes and of easier access. The result has been not only to increase the knowledge of the characters of the species, but to make possible the separation of several varieties (or forms), most of which were segregated by King (1887–1888).

Rafinesque (1838) placed *F. glomerata* in the subgenus *Sukeon,* which has not survived. Miquel (1848) located the species incorrectly in the genus *Covellia* (now a subgenus). Later (1867, p. 297) Miquel transferred *glomerata* back to *Ficus*. Other synonyms will be mentioned under the alleged varieties.

Two suggested but non-valid synonyms of *F. glomerata* were *Caprificus aspera latifolia* Rumph. and *F. cunia* Hamilton. The former probably is *F. wassa* Roxb., according to Roxburgh (1832, p. 539) and Merrill (1917, p. 193). *F. cunia* is an independent species, according to Corner (1933, p. 21) and others.

Homonyms of *F. glomerata* have been allocated as follows: Wallich, Cat. no. 4511 C in part to *F. saemocarpa* Miq., according to King (1887–1888, p. 181); Blanco, to *F. minahassee* Teysm. & De Vries, by Merrill (1923, p. 58); Hort. Berol. 1846, to *F. frangulina* Kunth and Bouché, by Kunth (1846, p. 19); Hort. Buit. ex King, to *F. variegata* Blume, by King (1887–1888, p. 169); Elmer, to *F. garciae* Elmer, by Elmer (1908) and Merrill (1923, p. 52). *F. glomerata* F.-Villar is doubtful, according to Merrill (1923, p. 69).

CHARACTERS OF FICUS GLOMERATA

The principal characters of *F. glomerata* are summarized here in order that those of *F. racemosa* may be checked against them. Characters are included which belong to such so-called varieties as seem to be valid. For additional details of flowers and receptacles see Corner (1933).

Tree, usually growing near water, to 18.5 m. high, evergreen or deciduous according to location; trunk thick, often divided near or at the base, sometimes buttressed; bark thick, smoothish, gray to reddish-brown; head sometimes thin, branches erect and spreading, aërial roots small or absent; twigs bare becoming scurfy, or hairy sometimes becoming bare; latex very milky; scales of terminal buds scurfy or hairy, elongating somewhat with the opening buds, sub-persistent; leaves alternate or sub-opposite; membranous; petioles 1.5–8 cm. long, pubescent to scurfy, or remaining pubescent; blades elliptical, ovate, or ovate-lanceolate, rarely obovate; 6–20 × 2–8 cm. in size (examples: 9.5 × 4, 13.5 × 6, 15 × 5.5 cm.); apex gradually narrowed or slightly acuminate, obtuse; base rounded, or slightly and gradually narrowed with curved sides, or cuneate and obtuse; margin entire or rarely indistinctly serrate near the apex; surfaces glabrous or hairy, under surface paler than upper one, minutely dotted with spots which become pale and tuberculate when dry; one pair of basal veins making an angle of about 80°, extending ⅓ to ⅖ the length of the blade; 6–10 sets of lateral secondary veins, making an upper angle of 50°–60° with the primary midrib, not forking and uniting near margin into an inframarginal vein, but appearing to fade away in fresh leaves; in dry leaves seen to unite with the nearest secondary veins by transverse veinlets; an irregular reticulum and sometimes a checkered background visible in dry leaves; figs edible but not valuable: borne from tubercles on the lower part of the trunk and the main branches, on leafless, crooked, thick, long or short, jointed and bracted twigs; appearing to form fasciculate clusters or compound (rarely simple) racemes; receptacles green to red, downy or sometimes becoming bare, about 2–5 cm. in diameter if almost globose, sometimes ovoid or obovoid and 2.5–5 cm. long, rounded at the apex or slightly umbonate with 5–6 apical bracts which close the mouth; eventually slightly depressed or truncate at the apex and usually turbinate or pyriform in general shape; base more or less narrowed into a stipe separated from the peduncle by a collar of 3 basal bracts, or the stipe absent and the basal bracts located at the base of the body of the receptacle; peduncles stout, 2 mm. to 2 cm. in length, bare or pubescent; male, female and gall flowers in the same receptacle, male flowers bearing two stamens.

The combination of clustered figs and diandrous male flowers places *F. glomerata* in the subgenus *Neomorphe*. The presence of three kinds of flowers in the same receptacle is almost unique in *Neomorphe* and so is a valuable distinguishing feature. Other significant characters are the red figs, the ovate blades which vary slightly in proportions but not much in shape, the long basal veins, the fading-away of the main lateral veins and the almost invisible smaller veins in fresh leaves, and the transverse and bent veinlets and the pale dots in dry leaves. These leaf characters are shown in most illustrations of the species. See also figure 1 A.

ALLEGED VARIETIES OF FICUS GLOMERATA

F. glomerata. The type of *F. glomerata* as described and pictured by Roxburgh (1798) may be separated from the summary above by its petioles to 5 cm. long, its elliptical blades to 16 ×6.5 cm. in size, almost equally narrowed at the ends, glabrous on both surfaces and bearing green dots on the under surface; and by its almost globose receptacles about 4 × 3.5 cm. in size, with a rounded apex closed by scales, and a rounded, rarely narrowed base separated by close bracts from a peduncle to 2.5 cm. long. The only hairiness mentioned by Roxburgh is the "down" of the receptacle. He speaks of "racemes compound, or panicled," but illustrates only the latter type.

The distribution of the typical variety is all India, including the sub-Himalayan states to the north; Ceylon, Burma, the Malay Peninsula, and Indo-China. Writers on these regions and living and herbarium specimens add the following to Roxburgh's characterization: ovate (although rather narrow) blades granulated beneath when dry, sometimes stipitate as well as pedunculate receptacles, and an immature pubescence of all parts which eventually disappears from all except the receptacles. The other mature parts are distinctly glabrous and some of them are scurfy.

F. glomerata var. *chittagonga.* Miquel described *F. chittagonga* from herbarium specimens collected in Chittagong. Kurz (1877) characterized it from that region and Burma. King named it a variety of *F. glomerata* and located it in Chittagong and Bengal; but later (1888b) called it a "definable form." As he follows this statement with a reference to var. *elongata* he may be presumed to use "form" in the sense of *forma,* and not as a vague term of classification. Gagnepain (1928) described var. *chittagonga* from Annam and Laos, Indo-China. Specimens 3953 and 11836 of the Herbarium of the Paris Museum, collected in Annam and Laos respectively by the same collector (Poilane) of whom Gagnepain spoke, and studied at the New York Botanical Garden, are probably of *chittagonga,* although labeled *F. glomerata.*

A specimen of Corner's, Singapore Field No. 26135, resembles No. 11836 and may be the original of his description (1933) of *F. glomerata.*

From the above sources *chittagonga* apparently is characterized by an ovate blade, a smaller pyriform receptacle than that of the type, and a hairy peduncle 2–8 mm. long. There is a general white-hairiness of all immature parts which eventually almost disappears, but which seems more pronounced than in the type. But three specimens of *F. glomerata* from the Punjab, seen in New York, showed a similar white-hairiness, and one of them an ovate blade. A receptacle and peduncle resembling that of No. 3953 (above) was found in *W. Koelz 1333.*

The conclusion of this paper is that *chittagonga* is not a variety but merely a white-hairy form, and that it is not confined to the regions mentioned above. Consequently its distribution has been added to those here given for the typical form.

F. glomerata vars. *miquelii* and *goolereea.* King (1887–1888, p. 174. *pl. 218 B*) created var. *miquelii,* saying only that it had leaves like those of *F. glomerata* proper and densely white-pubescent receptacles, and that it was found in dry situations over plains of India and west into the Punjab. He gave *F. goolereea* Roxb. as a possible synonym. His plate shows a leaf which slightly resembles that of the typical *F. glomerata,* and globose axillary figs. 2.5 cm. in diameter and bearing an erect crown of bracts at the apex. It is hard to imagine how a species with only axillary receptacles can be included in subgenus *Neomorphe.* Later (1888b) King omitted var. *miquelii,* although he was writing of Indian species of *Ficus.*

F. goolereea was first listed by Roxburgh in 1814 and was placed under the heading of trees having solitary or paired receptacles. The species was validly described in Roxburgh, Fl. Ind. **3**: 538. 1832. It was said to have opposite, serrate, downy, obovate leaves; and "fruits" in axillary pairs, long-peduncled, nearly globose, downy and with an elevated scaly margin. Twenty pages in this book separate *F. goolereea* from *F. glomerata.* Although this species seemed to differ from *Neomorphe* it was spoken of as a "definable form" by King (1888b), as a synonym of *F. glomerata* by a few writers, and as one of the varieties of that species by Domin (1921). No specimens have been seen by me and the allocation appears insufficiently verified by authorities.

F. glomerata var. *mollis.* Miquel described this as *Covellia mollis,* basing it on a Javan specimen. At first he declared that the receptacles were axillary, but later (1867, p. 283), having examined specimens from Sumatra and Timor he stated that the figs were mostly subracemose on leafless branches. At this time he transferred the species to *Ficus* and cited the herbarium name *F. trichocarpa* as a synonym.

When King made var. *mollis* he said only that it was pubescent on both blade surfaces and was native to Java. Later (1888b) he mentioned it as a "definable form." Koorders & Valeton (1906) accept King's variety, but also speak of it as perhaps a form of var. *elongata,* with which it is found in some stations. However, Koorders (1912) mentions var. *mollis* King, and the Atlas of Koorders & Valeton (1916, *pl. 781*) shows a diagram of the trunk of var. *mollis* which branches above the base, in contrast to one of var. *elongata* King, which divides at the base.

A specimen seen in New York, no. 1032 of *Plants of Sumatra,* W. N. and

C. M. Bangham, collectors, evidently is this variety, although labeled *F. glomerata*. The leaf has a petiole 4.3 cm. long, and a blade 15 × 5.5 cm., narrowed at each end, with almost equal apical and basal halves, and the typical veining of *F. glomerata*. There are about 10 sets of lateral secondary veins. The body of the receptacle measures about 3 × 2.5 cm., is slightly depressed at the apex, and is narrowed at the base into a peduncle 5 mm. long, which grows from a tubercle on a branched raceme. The tree, according to the label, was 12 m. tall, and the fig was light green. But specimen no. 938 of the same collection and collectors had red figs. All parts are white-hairy except the mature blades and wood.

Domin (1921) speaks of this as *F. glomerata* var. *mollis*, and other writers cite *F. mollis* Miq. as a synonym of *F. glomerata*.

F. glomerata var. *elongata* was characterized by King as having oblong, acute leaves 17.5 cm. long, and receptacles near *F. lanceolata*, but "not ridged not warted." This phrase is expressed in such poor English that it may have been misprinted. Perhaps it should read "ridged, not warted," since Koorders & Valeton (1916, *pl. 781*) show receptacles which answer that description.

Koorders & Valeton (1906 and 1916) have characterized this variety, and have allocated to it the insufficiently described and long misunderstood *F. lucescens* Blume, and *Urostigma lucescens* (Blume) Miq. Var. *elongata* has long, narrow blades like those of var. *mollis*, but glabrous or becoming so. The petioles may reach 4 cm. in length. The globose or obovoid receptacles measure about 4.5 cm. in greatest diameter, have an apex closed with five bracts and a base narrowed a little to a thick peduncle at least 1.5 cm. long. The authors state the distribution as Java and Sumatra and assert that varieties *mollis* and *elongata* are the only representatives of *F. glomerata* in Java. Domin (1921) also accepts this variety.

The position of *F. vesca*. *Ficus vesca* is an herbarium name given to an Australian tree by F. von Mueller, but published by Miquel. It has been used also by Domin (1921).

Most Australian writers, however, have called the tree *F. glomerata* Willd., and have cited *F. vesca* as a synonym. Although Domin confirmed the connection of *F. vesca* with the so-called Australian *F. glomerata* he was not sure that the latter was the same as the Indian *F. glomerata* Roxb. But Hiern (1901) applied the authorship of Roxburgh to the Australian *F. glomerata* and vindicated it by a characterization of leafless "flowering" twigs from trunk and large branches, "flowers in racemes," diandrous male flowers, and the presence of both male and female flowers in the same receptacle. The force of this last character is weakened by the statement that the female flowers all are occupied by gall insects; since it is common for male and gall flowers of *Ficus* to be found together. Nevertheless, the combination of other characters indicates the relationship of the Australian to the Indian form.

Hiern did not refer to *F. vesca*, but described receptacles of the sort illustrated by F. M. Bailey (1913, *pl. 495*). This description, taken from Daniel Solander's notes, was of a tree which had been found in New South Wales in 1770 by Sir Joseph Banks and had been given the herbarium name of *F. caudiciflora* by Solander. The text which accompanied Bailey's plate (p. 504) listed both *F. vesca* and *F. caudiciflora* as synonyms of *F. glomerata* Willd. and referred to Hiern.

But *vesca* is not a synonym of *F. glomerata* proper, for its leaves measure about 15 × 6 cm., are more nearly ovate, and more frequently have a rounded base. Its red figs measure about 2.5–5 cm. in length. They are ovoid, obovoid, or oblong, have about 10 apical bracts, and may have a short basal stipe separated by a collar of basal bracts from a peduncle about 1 cm. long. Leaves like those pictured by Bailey were seen by me in an Australian specimen in the Arnold Arboretum. There the fig was of the same shape, but had a shorter peduncle and no stipe.

The distribution of *vesca* is Queensland, New South Wales, and the Northern Territory.

COMPARISON OF CHARACTERS OF FICUS RACEMOSA AND FICUS GLOMERATA

Both distribution and the characters of the acceptable varieties of *F. glomerata* show that it is with the typical form that *F. racemosa* should be compared.

Almost all characters reported for *F. racemosa* are included in a description of the type of Roxburgh's species. Exceptions are: location in sandy soil [but Nehrling (1944) stated that *F. glomerata* in Florida grew well in dry soils], red color of cortex and latex when exposed to air, the scattered short twigs mentioned by Thunberg (but perhaps omitted by other writers because they seemed unimportant or variable), the tender soft leaves (perhaps the same as *membranous*), and the sessile figs spoken of by Vahl (but corrected by Smith in 1810). Of course the most striking difference is in the racemose clusters of *F. racemosa*. The differences in interpretation of that adjective have been already mentioned. Corner's very full description of receptacle-bearing twigs gives some suggestion of racemes, and *vesca* is said to have subracemose clusters. Unfortunately no adequate descriptions of flowers seem to have been published for *F. racemosa*.

Finally, a study of herbarium specimens and of living trees of *F. glomerata* has resulted in the finding of leaves (see figure 1 A) and figs, and even a part of a cluster which appeared like a simple raceme; all resembling those of *F. racemosa*.

ADDITIONAL EVIDENCE FROM LITERATURE

Literature furnishes evidence in addition to the characters just discussed: evidence perhaps not always conclusive, but at least significant.

1. *Atty-alu* Rheede is almost universally accepted as the basis for *F. racemosa*. It was located on the southwest coast of India not too far from the latitude of the Coromandel Coast on the southeast. *F. glomerata* now has been reported from most sections of India, including the south and the Bombay region.

2. *Atty-alu*, when run through Corner's key to Malayan species of *Covellia* and *Neomorphe*, the two subgenera of *Ficus* which are characterized

by clusters of figs on trunks and branches, leads to *F. glomerata.* No other species there described has its combination of size and shape of receptacle, and length of peduncle.

3. *Atty-alu* is suggested or cited as a synonym of *F. glomerata* by Hamilton (1822), who said that Roxburgh so considered it; by Kosteletzky (1831), Graham (1839), Pritzel (1855, 1866), and Balfour (1862, 1870).

4. Trimen (1885) said that *Atti* is a vernacular name in Ceylon for *F. glomerata.*

5. Very few scientists stated that they had seen *F. racemosa* L.

6. The reports of that species in botanical gardens were unsatisfactory.

7. *F. racemosa* Willd. (which, however, may not be *F. racemosa* L.) is suggested or cited as a synonym of *F. glomerata* by Hamilton (1822), Graham (1839), and Balfour (1862, 1870).

8. *F. racemosa* Aiton (1813) was said by Hamilton (1822) to be *F. glomerata.*

9. *F. racemosa* Hb. Wight in Wall. Cat. n. 4549 was said by King (1887–1888, p. 173) to be *F. glomerata* Roxb.

10. *F. racemosa* Hb. Rottler in Hb. Kew was said by King (1887–1888, p. 183) to be *F. glomerata* Willd.

11. Reports of *F. racemosa* began to die out many years after *F. glomerata* was first described.

CONCLUSIONS

1. Evidence from descriptions of *Atty-alu* Rheede, the prototype of *Ficus racemosa* L.; from descriptions and reports of *F. racemosa;* from descriptions, herbarium specimens and observation of living trees of *F. glomerata;* and from opinions expressed in literature as to these species proves that *F. glomerata* Roxb. belongs to the species *F. racemosa* L.

2. The reasons for the disappearance from botanical literature of *F. racemosa* probably are: the scarcity of first-hand observation of the species, the emphasis in descriptions on the cluster as a raceme and the change in original meaning of *racemus* from a usually grape-like cluster, and the announcement of the species *F. glomerata* in which the fruiting cluster almost never was a raceme.

3. Four varieties of *F. racemosa* are here recognized. Var. *typica*, the original *F. glomerata*, corresponds to *F. racemosa* L. It is native to India, Ceylon, and the countries east of the Bay of Bengal. It is eventually an almost entirely glabrous tree, with ovate or elliptical leaf-blades. A form, *chittagonga,* is more persistently hairy. Var. *vesca* is native to Australia. It has ovate blades and ovoid or oblong, usually stipitate, figs. The varieties of Sumatra, Java and Timor are *mollis* and *elongata.* They are characterized especially by their long narrow elliptical blades. The former variety is hairy; the latter eventually glabrous.

4. The alleged varieties *miquelii* and *goolereea* are rejected.
5. The synonym of *F. racemosa* and its varieties is as follows:

FICUS RACEMOSA L. Sp. Pl. 1060. 1753.

FICUS RACEMOSA L. var. **typica** Barrett, var. nov.

Atty-alu Rheede, Hort. Mal. **1**: 43. *pl. 25*. 1678.

Ficus malabarensis folio oblongo, acuminato, fructu vulgari aemulo Syen, *in* Rheede, Hort. Mal. **1**: 44. 1678.

Ficus foliis ovatis acutis integerrimis, caule arboreo, fructu racemoso L. Amoen. Acad. **1**: 30. 1749.

Ficus glomerata Roxb. Pl. Corom. **2**: 13. *pl. 123*. 1798.

Covellia glomerata (Roxb.) Miq. Lond. Jour. Bot. **7**: 465. 1848.

? *C. racemosa* (L.) Walp. Ann. **1**: 731. 1848–1849.

F. chittagonga Miq. Ann. Mus. Bot. Lugd.-Bat. **3**: 228. 1867.

F. glomerata var. *chittagonga* (Miq.) King, Ann. Bot. Gard. Calcutta **1**: 174. *pl. 219*. 1888.

FICUS RACEMOSA var. **elongata** (King) Barrett, comb. nov.

F. lucescens Blume, Bijdr. 444. 1825.

Urostigma lucescens (Blume) Miq. Fl. Ind. 1^2: 341. 1859.

F. glomerata var. *elongata* King, Ann. Bot. Gard. Calcutta **1**: 174. 1888.

FICUS RACEMOSA var. **mollis** (King) Barrett, comb. nov.

Covellia mollis Miq. Lond. Jour. Bot. **7**: 466. 1848.

F. mollis (Miq.) Miq. Ann. Mus. Bot. Lugd.-Bat. **3**: 283. 1867. (Not Vahl.)

F. trichocarpa Hb. Mus. Paris. ex Miq. Ann. Mus. Bot. Lugd.-Bat. **3**: 283. 1867.

F. glomerata var. *mollis* King, Ann. Bot. Gard. Calcutta **1**: 174. 1888.

FICUS RACEMOSA var. **vesca** (Muell. ex Miq.) Barrett, var. nov.

F. vesca Muell. ex Miq. Jour. Bot. Néerl. **1**: 243. 1861.

F. glomerata of Bentham and many other writers on Australia.

F. caudiciflora Solander MS ex Hiern, Jour. Bot. **39**: 5. 1901.

The library work for this paper has been done mostly at the New York Botanical Garden. Herbarium specimens have been examined there and at the Arnold Arboretum, the State Agricultural Experiment Station at Gainesville, Florida, and the United States National Herbarium in Washington. Living trees have been studied at the United States Plant Introduction Station at Chapman Field, south of Coconut Grove, and on the estate of Mrs. Charles T. Simpson in Miami, Florida. I am grateful for the permission to use these facilities and for the help given me by those in charge of them.

MONTCLAIR, NEW JERSEY

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STUDIES IN THE CARYOPHYLLACEAE—I

BASSETT MAGUIRE

To make them immediately available for use by Mr. I. W. Clokey for his Flora of the Charleston Mountains, the following proposals of new entities or combinations have been extracted from more detailed papers. The fuller supporting considerations will appear as publication date becomes available for them.

Arenaria filiorum Maguire, sp. nov. Plantae annuae; caulibus tenuis, numerosis, 2–5 cm. altis; foliis 5–10 mm. longis, triquetribus, subcrassulis, 1-nerviis, obtusis; inflorescentibus 1-pluribus floribus; cymis non symmetricalibus; sepalis 3.5–4.8 mm. longis, ovato-lanceolatis, valde 3-nerviis, stylibus 3 (4); capsulis chartaceis, ovatis, ad basim dehiscentibus; seminibus numerosis 0.7–1.0 mm. longis.

TYPE: Common, gravelly beach, Navajo Lake, Iron County, Utah, July 13, 1940, *Maguire 19472*. New York Botanical Garden.

ARENARIA CONGESTA Nutt. ex Torr. & Gray var. **charlestonensis** Maguire, var. nov. Caulibus 10–12 cm. altis; foliis 1.0–1.5 cm. altis, 0.5–0.8 mm. latis, recurvatis vel aculeatis, basilaribus; inflorescentibus dense congestis; sepalis 4.5–5.5 mm. longis, acutis, pungentibus.

TYPE: Harris Spring Summit Road, 18 mi. south Kyle Canyon, 8500 ft., Charleston Mountains, Clark County, Nevada, August 2, 1938, *Train 2256*. New York Botanical Garden.

ARENARIA MACRADENIA S. Wats. subsp. **macradenia** Maguire, subsp. nov. *A. macradenia* S. Wats. Proc. Am. Acad. **17**: 367. 1882, as to type.

ARENARIA MACRADENIA S. Wats. subsp. MACRADENIA Maguire var. **macradenia** Maguire, var. nov. *A. macradenia* S. Wats. Proc. Am. Acad. **17**: 367. 1882, as to type. *A. congesta* var. *macradenia* (S. Wats.) M. E. Jones, Proc. Cal. Acad. II. **5**: 626. 1895. *A. Fendleri* var. *glabrescens* S. Wats. in Bot. King's Expl. **5**: 40, in part. 1871.

ARENARIA KINGII (S. Wats.) M. E. Jones subsp. **rosea** Maguire, subsp. nov. Caudicibus pauciramosis; inflorescentibus strictis, paucifloribus; petalis roseis.

TYPE: Hilltop, yellow pine belt, Lee Canyon, 2600 m., Charleston Mountains, Clark County, Nevada, August 4, 1935, *I. W. Clokey 5560*. New York Botanical Garden.

THE NEW YORK BOTANICAL GARDEN
NEW YORK

INDEX TO AMERICAN BOTANICAL LITERATURE

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(exclusive of fungi)
(See also under Genetics: **Love**; under Paleobotany: **Bradley**.)

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A PHYSIOLOGICAL AND BIOCHEMICAL BASIS FOR RESEARCH ON FUNGICIDES

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The necessary relationships between the lethal or static effects of some chemicals on fungi and the physiological and biochemical reactions of these organisms are often overlooked in the development of new fungicides. Yet a knowledge of these processes might furnish a rational basis for research on fungicides. A substance must have many specific properties to be an efficient toxin for fungi and these properties will vary with the commercial purpose for which the chemical is used. Nevertheless, one primary attribute is common to all fungicides no matter what their use; the chemical must be detrimental to the fungus. Most often, this is accomplished by preventing spore germination, sometimes by preventing growth or by the destruction of the mycelium, and it is possible that occasionally the prevention of reproduction could check the spread of the fungi.

Current techniques for the discovery of new fungicides are mainly empirical and are largely a matter of trial and error. The net is spread wide in the search for new toxic compounds and almost any chemical which is available is tested. Sometimes each new chemical which is produced in industrial laboratories is assayed for fungicidal properties as a matter of general routine. At other times the direction of research is guided by the nature of an industry's by-products in an attempt to find a use for such materials. Often the known toxic properties of chemicals toward other organisms such as bacteria and insects determine the types of materials which are synthesized. When a compound with good fungicidal properties is found, the efforts of the research group are intensified toward the production of its homologues and analogues, in a search for greater fungicidal power and for other properties. Many such related compounds are then synthesized to discover the functional groups in the molecule which are responsible for its toxicity. Attempts have been made to correlate the structure of organic compounds with their toxicity in the hope of discovering means of predicting the toxic properties of a chemical. Until now this goal has not been realized and such relationships between structure and toxicity remain unknown for the most part. Slight changes in a molecule often greatly alter its fungicidal properties, and the combination of two toxic groups in a compound might not only fail to increase its toxicity, but might even decrease it.

What are the reasons for our dependence upon purely empirical methods in the search for more efficient fungicides? One of these factors has been the

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paucity of information available on the physiology of the fungi. This void in our knowledge of the intimate life processes of the very organisms which we are seeking to attack has forced the investigator in the past to rely upon general protoplasmic toxins, such as the copper and mercury compounds, which were supposed to precipitate proteins (12) ; but even with these the nature of toxic activity remained a mystery. To fill the gap and allow a reasonable approach to the fungicide problems, attention should be directed to the fundamental structure and metabolic processes of the fungus. Horsfall and Zentmeyer (10) adopted a rational approach of this type for the study of fungicide activity. They determined a number of generic compounds which normally occur in all cells, and then tested the toxicity to fungus spores of various reagents which are used for the analysis of these materials. These reagents were found to possess good fungistatic properties. A more exact knowledge of the fungus is, however, necessary to make such studies fruitful. Interest, as far as possible, should be centered not only on the characteristics common to all living cells, but also upon their specific modifications and biological transformations within the fungus. What is sought in agricultural sprays and dusts are materials which injure the fungus spore while not materially affecting the host plant. Differences in physiology between host and pathogen are important and it is upon the presence of such differences that the ideal fungicide, which is not injurious to the host plant, will be synthesized.

Attention should be directed especially to the spore, if protectants against fungi are sought. The purpose of most fungicides is to prevent the entrance of the fungus into the host or the production of mycelium, by inhibiting the germination of the spores. Too often germination is considered merely as an absorption of water resulting in the dilution of the protoplasmic elements of the spore with a consequent swelling of the cell to produce the germ tube. This interpretation would be analogous to the swelling of colloidal substances in contact with water. However, germination is a more delicate and dynamic process. Even before any visible sign of a germ tube is evident, respiration takes place in the spore (15). The metabolic processes function even in this early stage of development and food reserves of the cell furnish energy and material for growth. Some spores, such as those of *Sclerotinia fructicola*, require an external source of carbon such as dextrose or alcohol for germination (13). Very low concentrations of mineral salts at times enhance the germination of spores, and antagonistic effects of different salts have been recorded. The presence of many of the physiologic processes normally associated with growth is thus indicated in the spore, before growth is microscopically evident. Specific compounds for disturbing such processes would then be the goal of fungicide research.

Information on the composition of the cell wall and the cell membranes, and on their permeabilities, could also be valuable in the synthesis of fungicides. It would provide the data for the synthesis of organic chemicals which contain the proper balance of hydrophilic and hydrophobic groups, to insure the passage of the toxic molecules through the cell membranes and their arrival at the seat of specific protoplasmic activity.

Recent investigations on the therapeutic activity of 8-quinolinol in the wilt diseases (21) indicate the importance which a knowledge of the mineral nutrition of the fungus can play in the treatment of diseases. When 8-quinolinol was added to the medium the growth of *Fusarium oxysporum* f. *lycopersici* was inhibited; but when an excess of zinc was added, the *Fusarium* grew well. The explanation was proposed that the zinc is necessary for the growth of the fungus and that it is precipitated by the reagent, thereby depriving the fungus of an essential element.

Another area of knowledge in which our information of the fungi is limited is the vitamin requirements of these organisms and their role in the respiratory and metabolic mechanisms. Except for vitamin B_1 and biotin little information is available on the fungal relationships of the other coenzymes, though some studies have been conducted on riboflavin. The fat-soluble vitamins also have been neglected. Information on the vitamins essential to fungi, whether synthesized by the organism itself or obtained from its nutrients, could play an important part in furnishing valuable clues for the synthesis of fungicides. Altering the structure of a vitamin to produce analogues of that compound sometimes converts the material into an antivitamin which inhibits the growth-promoting activity of the original compound. Robbins (17) showed that pyrithiamine, the pyridine analogue of thiamine, inhibited the growth of some fungi. The substitution of a dulcityl for a ribityl group in the molecule of riboflavin converts the compound into galactoflavin, which inhibited the growth of rats (2). Other analogues are known to have antivitamin properties for animals (3). Merely supplying an adequate excess of the vitamin usually overcomes the detrimental effects of an antivitamin (20). Such relationships may exist for vitamins still unknown but peculiar to some fungi. If their presence in fungi were ascertained, one direction of fungicide research could be the development of antivitamins for use as fungicides. Unpublished studies by the writer have indicated the absence of vitamin C in some fungi, yet this vitamin occurs in most plants. Might not the converse of this occur and a vitamin be found which is essential to and manufactured by the fungus but not essential to its host? Such a relationship would furnish a target at which the research for therapeutic agents as antivitamins could be directed. Then, if an inhibitor for this growth promoter was found it could be injected into the host and prevent the growth of the fungus while not disturbing the metabolism of the host plant.

The enzyme systems of the fungi also deserve more intensive study.

Many of the hydrolyzing enzymes have been identified but, except for the yeasts, information on the respiratory enzymes is very scarce. The specificity of enzyme poisons is very acute and such toxins can even selectively inhibit different respiratory enzymes in the same system. Potassium cyanide and sodium azide will block the activity of the cytochrome oxidases, while phenyl urethane and amyl alcohol inhibit the dehydrogenases (12). It is probable that the activity of many of our bactericides and fungicides is due to their ability to combine with an enzyme and so inhibit its activity. Even the activity of the mercury compounds, whose fungicidal properties have been attributed to their precipitating action upon proteins, may instead be specific enzyme inhibitors. An intimate investigation of the bactericidal effect of such compounds (4) has revealed that the toxic activity of mercury compounds could be prevented by the addition of the omnipresent tripeptide, glutathione, and indicates that mercury plays a more specific role in interfering with the oxidation-reduction mechanisms of the living cell than is sometimes considered. Hellerman, Chinard, and Dietz (8) showed that organic mercurials combined with the sulfhydril groups of urease and inhibited its activity. Another mode of action of a fungicide could be its competition with an enzyme for some essential metabolite, or with an essential metabolite for an enzyme itself, as has been indicated for the bacteriostatic action of the sulfanamide drugs which compete with p-amino benzoic acid (16). Enzyme systems have a vital function in almost every life process. One of the most vulnerable systems and the one about which more information is available than any other is the enzymes of intermediate carbohydrate metabolism. This chain of degradation can be blocked at many points. Information of the paths of degradation of glucose in both the pathogenic fungi and their green host plants (and many possible paths are known) would indicate whether such differences could be utilized by specific enzyme poisons to block the respiration of the parasite and not impair the vigor of the host. A knowledge of the enzyme systems may be useful in a still different manner. Instead of hindering the activity of such systems, therapeutic advantage might even be obtained by promoting an enzyme process (14).

Recent developments in the field of antibiosis have indicated another approach to the development of fungicides which is dependent upon our knowledge of the biology of the organism. Some of the antibiotics, such as clavacin (5, 11) and gliotoxin (19) are toxic to fungi. Brian and McGowan (1) recently isolated a new compound from *Trichoderma viride* which is one hundred times more toxic to spores of *Botrytis allii* than is mercuric chloride. Studies on the structure of the antibiotics to reveal the particular group responsible for their fungistatic activity, and their mode of action, could indicate types of synthetic organics which might be even more toxic than their naturally occurring homologues. Geiger and Conn (5), for example, observed that both clavacin and penicillic acid contained an α, β unsaturated ketone, a grouping which readily combines with sulfhydril groups. The knowledge that these antibiotics were also inactivated by cysteine led the investigators to the hypothesis that synthetic organic chemicals of similar structure should be good fungicides. Several such materials were found, of which acrylophenone, benzalacetophenone, and furfuralacetophenone proved effective, and also reacted with sulfhydril groups. Acrylophenone especially had marked fungistatic power, with an activity in the same order as clavacin.

Many other physiological factors, either chemical, physical, or their combination in the fungi, deserve closer study. Very little is known of the electric charge on a spore. Studies by Seifriz and Gottlieb (18) on the cataphoretic behavior of spores indicated differences between *Sclerotinia fructicola* and *Fusarium oxysporum* f. *lycopersici*. Such differences might influence the behavior of charged organic fungicides and determine the relative effectiveness of particular fungicides such as the cationic quaternary ammonium compounds against spores of two species. The redox potentials in fungi have received little scrutiny, yet they are of utmost importance in the energy transformations of the cell. The efficiency of one fungicide, Spergon (tetrachloroquinone), an excellent seed treatment, has been linked to its oxidative properties (9). Attention should also be focused on the surface phenomena in these microorganisms and the effect on the spore of various reagents which alter surface tension.

One of the puzzling phenomena encountered by plant pathologists is the specificity of fungicides. In the laboratory assay this specificity is expressed as differences in concentration of a chemical which is necessary to inhibit spore germination of different species. Often the concentration of chemicals required to inhibit germination of *Macrosporium sarcinaeforme* is as much as sixteen times that required to inhibit *Sclerotinia fructicola*. This phenomenon cannot be entirely explained by the large size of the spore of the former compared to that of the latter, for occasionally the converse occurs and a greater concentration of another material is necessary to inhibit *S. fructicola* than *M. sarcinaeforme*. *Glomerella cingulata*, with small spores, is relatively tolerant to hydrogen sulfide, while the larger spores of *S. fructicola* are very susceptible (9). Similar differential effects of protective sprays on two pathogens have been reported in field studies. This sometimes occurs even when both pathogens are parasites of the same host. A recently developed fungicide, zerlate (zinc dimethyldithiocarbamate), very efficiently controls the early blight of potatoes but is only moderately effective against late blight of potatoes (7). Do some fungi possess protective reactions against toxins, such as have been demonstrated for animal tissues? The tolerance of a fungus to a particular chemical could be due to its ability to oxidize, to reduce, or to combine the toxicant with some normal constituent of its protoplasm. It might thereby form an innocuous substance which can be metabolized or eliminated by the organism. The mammalian body makes use of all three protective devices; cyclohexane is oxidized to adipic acid, quinone is reduced to hydroquinone, and benzoic acid is conjugated with glycine to form hippuric acid (6).

The emphasis on fundamental studies in the physiology and biochemistry of the fungi as an aid to fungicide development is not proposed as an alternative method to the current empirical research. It is suggested, rather, as a guide for such investigations into areas of biochemical reactions which are concerned with the vital processes of the fungus and where the empirical methods could be most effectively employed. In addition, fundamental studies of the living organism can furnish clues on the type of organic molecule which effectively inhibit the biochemical reactions necessary to the life of the organism. Finally, such research can put plant protection on a basis of rational scientific principles.

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NOTES ON THREE SOUTH AFRICAN RUSTS

M. J. THIRUMALACHAR[1]

Some collections of rusts were received by the writer from the Mycological Herbarium of the Union Department of Agriculture, South Africa, through the kindness of Dr. A. M. Bottomley and Dr. E. M. Doidge. Before the material was incorporated in the writer's herbarium a brief study of it revealed certain interesting features. Observations pertaining to three of the rusts included in the collections are presented in this paper; they refer either to finding of new spore forms unrecorded in the original description of the species, or to the identity of the rust based upon the morphology of the spore forms as interpreted by the writer.

(1) A rust collection on *Grewia monticola* Sond. was sent to the writer tentatively identified as *Ravenelia atrides* Syd. (U.D.A. No. 32401). The type of *Ravenelia atrides* was collected by Pole Evans from South Africa on the leaves of *Grewia caffrae*, and is of interest on account of the fact that it is the only species of *Ravenelia* to parasitize a member of the Tiliaceae; most of the other species of the genus are parasitic on Euphorbiaceae or Leguminosae. While an authentic specimen of *R. atrides* was not available for study, a detailed examination of the specimen sent to the writer revealed that it was not congeneric with *Ravenelia* and therefore warranted restudy. Small bits of the leaf containing the sori were softened and embedded in paraffin, and good microtome sections were obtained. The sections were stained with Delafield's haematoxylin and permanent mounts were made.

The uredia are minute, sparsely distributed, erumpent, and pulverulent. They are paraphysate, the paraphyses marginal and incurved. The urediospores are ovate-ellipsoid, cinnamon-yellow, 20–26 × 15–20 μ. The epispore is hyaline, minutely and densely verruculose with indistinct germ pores (fig. 2). The telia are developed either in place of the uredia, in which case the marginal row of paraphyses is retained, or separately, in which case they are aparaphysate. In a young telium the teliospore mother-cells are grouped deep within the mesophyll tissue. These mother cells abstrict in basipetal succession chains of one-celled teliospores which adhere permanently both vertically and laterally to form a compact columnar crust. The apex of the teliospore head becomes expanded to form a flabelliform structure (fig. 1). These cushion-like heads of telia are usually single in each telium but very rarely more than one occurs in each sorus. They are approximately 130–167 μ high, 130 to 154 μ broad at the apex, and about 83–90 μ broad at the base of the telial head. The mature spores are sessile, one-celled, developed in catenations in basipetal successsion, yellowish-brown, smooth and measuring 11.5–21 × 8–12 μ. The apex of the terminal spores in the chain is thickened. In addition to the compact grouping of the teliospores, a thin layer of hyphal sheath (fig. 3) is found enveloping the telial crust which is found to impart rigidity and to retain the shape of the telial head. The structure of the telium clearly indicates that the rust is congeneric with *Dasturella*, recently described by Mundkur and Kheswalla (1943). The genus is characterized by subepidermal paraphysate uredia, the paraphyses being cylindric and incurved; and by possessing telia which are subepidermal, erumpent, with teliospores fascicled into large flabelliform crusts. Only two species are known for the genus so far, both of them leaf-parasites of bamboo. From a study of the structure of the uredium and telium, the South African rust on *Grewia monticola* is doubtless a species of *Dasturella*.

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[1] This paper was transmitted to the editor through the kindness of Dr. George B. Cummins, of Purdue University. In order to avoid long delay in publication, he has also cooperated in the reading of the proof and in certain minor editorial changes.

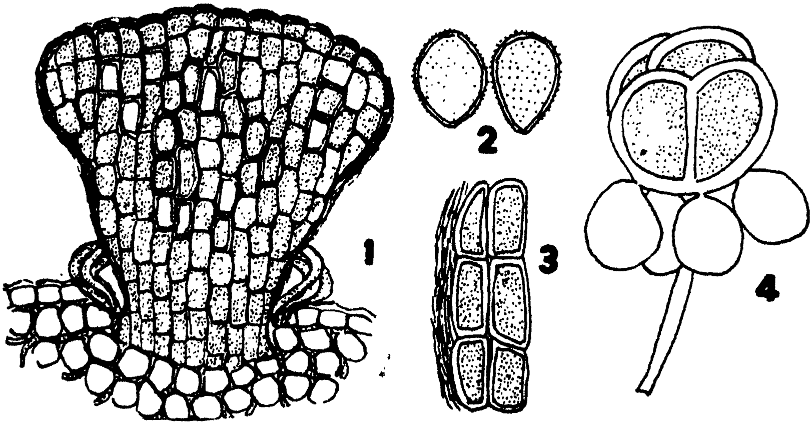

FIG. 1. Telium of *Dasturella Grewiac.* × 300. FIG. 2. Urediospores of *D. Grewiae.* × 500. FIG. 3. Margin of a telium of *D. Grewiae* showing the hyphal sheath which surrounds the telium. × 500. FIG. 4. Teliospore head of *Spumula Bottomleyae.* × 500.

From a specimen collected by Chevalier on *Grewia* sp. near Senegal, Africa, Cummins (1945) has recently described *Phakopsora Grewiae* (Pat. & Har.) Cummins as the perfect stage of *Uredo Grewiac* Pat. & Har. A small fragment of Doidge's collection of the *Grewia* rust (No. 32401) was sent by the writer to Dr. Cummins with the writer's remarks that it is a species of *Dasturella*. Through his kindess it was made known to the writer that the South African rust on *Grewia monticola* is identical with the Chevalier's collection studied by him and would therefore constitute the perfect stage of *Uredo Grewiae* Pat. & Har. It becomes clear, however, from the characters of the telia, that it is not a typical *Phakopsora*.

In the description of the genus *Dasturella*, Mundkur and Kheswalla (1943) state that the teliospores appear not to be one-celled and catenulate but are continuous structures composed of 3–6 superposed cells. This indicates that all the cells in a vertical row are of the same maturity. However, a study of the type of the genus, *D. divina* (Syd.) Mundkur & Kheswalla, obtained from the Herb. Crypt. Ind. Orient., and of fresh specimens collected in Mysore indicated that the spores in a vertical row are of different maturity and that new spores are added from the base in basipetal succession. Consequently the spores are one-celled and catenulate. The genus is distinguished from *Angiopsora* Mains in having an erumpent telium which is naked and flabelliform, as against the non-erumpent, lenticular telial crust of *Angiopsora*. On account of the possession of the characters mentioned above the rust on *Grewia monticola* is placed under *Dasturella* and a new combination *D. Grewiae* (Pat. & Har.) Thirumalachar is proposed.

Dasturella Grewiae (Pat. & Har.) Thirumalachar, comb. nov. *Uredo Grewiae* Pat. & Har. Jour. de Bot. **14**: 237. 1900; *Phakopsora grewiae* Cumm. Bull. Torrey Club **72**: 206. 1945.

Uredia hypophyllous, subepidermal, erumpent, pulverulent, with marginal, incurved paraphyses; urediospores ovate-ellipsoid, cinnamon-yellow, without distinct germ pores, 20–26 × 15–20 μ; epispore about 1 μ thick, minutely and densely verruculose, with indistinct germ pores. Telia developing within uredia or separately, subepidermal, erumpent and soon becoming naked, in flabelliform cushion-like crusts, 130–167 μ high, 130–154 μ broad at the apex, 83–90 μ broad at the base; teliospores developed in basipetal catenations, the spores coalescing vertically and laterally to produce a columnar, flabelliform, cushion-like head, one-celled, sessile, yellowish-brown, ovate to cuboid, moderately thick-walled, smooth, 11.5–21 × 8–12 μ.

On the leaves of *Grewia monticola* Sond., Experimental Station, Kelspruit, Tvl., South Africa, 2nd Aug. 1940 (U.D. No. 32401).

In her monographic studies on the South African rusts, a rust on *Albizzia versicolor* was described by Doidge (1926) as *Ravenelia Bottomleyae* Doidge, based on the collections made by Dr. Bottomley near Victoria Falls, S. Africa. The urediospores were noticed intermixed with the telia, being golden-brown, globose to ellipsoid, verruculate-echinulate, 30–42 × 25–27 μ. The telia are amphigenous, black, subepidermal, erumpent, and pulverulent. The teliospores are in pedicellate heads composed of 4–6 spores, the pedicels being very fragile. A portion of the type (U.D.A. 14166) was kindly sent to the writer by Dr. A. M. Bottomley, which made possible a study of the rust in some detail. The telial heads are mostly 6-spored, of which two are in the center and four are marginal. Occasionally, as noticed by Doidge also, there is only a single inner spore with two marginal spores. Mature spores are chestnut-brown, smooth, 27–30 × 25–33 μ. On each of the marginal spores, a single large, pendent, hyaline cyst is present. These swell in water and can be clearly observed in spore mounts stained with a dilute solution of Gentian violet. The pedicel is simple, hyaline (fig. 4), long, deciduous. The pedicel is attached directly to the spore and not to the fused portions of the cysts.

The genus *Spumula* Mains was erected by Mains (1935) for a leguminous rust on *Calliandra*. The genus is closely allied to *Ravenelia* Berk. and *Cystomyces* Syd. but has greater affinity with the former than with the latter. *Spumula* is, however, differentiated from *Ravenelia* by the absence of a compound spore head with compound pedicel. It resembles *Cystomyces* in the possession of a simple pedicel, but the stipe of *Cystomyces* is attached to the fused portions of the cysts and not directly to the spore as in *Spumula*.

A similar condition prevails in the telial heads of the rust on *Albizzia versicolor*, in which the pedicels are simple and not compound, and the attachment of the pedicel is directly with the spore and not with the fused portions of the cysts. The simple pedicel has also been figured by Doidge (*l.c.*) which clearly differentiates the rust from *Ravenelia* and secures a place for it in *Spumula*, proposed by Mains. Only two species are known in the genus so far, *Spumula quadrifida* Mains, the type of the genus with aecia and telia, and *S. Clemensiae* Arth. & Cumm., recorded in the Philippines by Arthur and Cummins (1936); the latter is a hemiform with uredia and telia. It is evident that the rust on *Albizzia versicolor* is also a species of *Spumula* on account of the possession of the characters already enumerated. A new combination, **Spumula Bottomleyae** (Doidge) Thirumalachar is proposed for its accommodation.

Skierka robusta Doidge was described by Doidge (1926) as parasitic on the leaves of *Rhoicissus rhomboidea* from South Africa. Only telia were reported, the teliospores being yellowish, lanceo-fusiform with acuminate apex, and adhering to form short columns 3–5 mm. in length. In the collection of the rust sent to the writer (U.D.A. No. 6628), large numbers of pycnia were associated with the telia, indicating that the rust is definitely a micro-form, the telia immediately following pycnia in development. Pycnia are amphigenous, minute, orange-yellow, distributed in concentric rings. Sections through the infected patch indicates that the pycnia are subepidermal in origin, broader than long, 230–320 µ broad, 120–140 µ high, with a narrow ostiole. There are no conspicuous ostiolar hyphae projecting. Pycnia have been recorded also for two other species of *Skierka*, viz. *S. Holwayi* Arth. and *S. cristata* (Speg.) Mains (Mains 1939).

In conclusion the writer wishes to acknowledge his grateful appreciation for the kindness of Dr. G. B. Cummins, Purdue University, U. S. A., for the benefit of valuable suggestions, and to Drs. E. M. Doidge and A. M.

Bottomley, Union Department of Agriculture, South Africa, for placing at the disposal of the writer the valuable material. Grateful thanks are due to Dr. L. N. Rao, Professor of Botany, University of Mysore, for kind encouragement. This part of the work was carried out as a research scholar of the University of Mysore.

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THE USE OF EMBRYOLOGICAL FORMULAS IN PLANT TAXONOMY

THEODOR JUST[1]

Cytogenetic data, especially chromosome numbers, are now regularly recorded in many systematic studies and have even made their way into floras. The same cannot be said, however, with regard to the laboriously accumulated information often referred to as comparative embryology (Schnarf 1931, Maheshwari 1945). Johansen (1945) has advanced objections to such "an excessively broad" application of the term embryology, because in many instances megasporogeny and megagametogeny (or, if both are treated at the same time, simply megagametogeny) alone are implied to the exclusion of real embryogeny, which begins with syngamy. Recognizing the validity of these objections, the broad use of embryology, though embracing actual stages of two successive generations, is perhaps justifiable in the light of the somewhat comparable usage of it by zoologists, the absence of another equally inclusive term, and the characterization of all phases of "pure" plant embryology given by Johansen himself (1945).

The use of embryology sensu lat. is actually necessitated by the great variety of embryological phenomena described to date and the desire to bring these under some common heading (Schnarf 1929). As the purely descriptive phases of plant embryology are largely completed, even though many orders and families remain to be investigated, the accumulated data have and will continue to be variously applied in other respects. One of these applications is the utilization of embryological knowledge for the improvement of the existing classifications of angiosperms (Mauritzon 1939; Schnarf 1931, 1933, 1937). Obviously, this aim cannot be attained on the basis of a single embryological character, i.e., the development of the male gametophyte, but only by the simultaneous evaluation of all significant embryological features, as is usually the practice with gross morphological and other characters. Originally Schnarf (1933) proposed the term "embryological diagram" for the entire set of important embryological characters of any group. This proposal of utilizing as far as possible embryological diagrams for taxonomic purposes was recently restated by Maheshwari (1945), who adopted the preferable designation "embryological formula" and promptly illustrated his views with a suitable example, the Alismaceae. The embryological formula of this family as drawn up by Maheshwari reads as follows:

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[1] The writer is greatly obliged to Drs. G. N. Jones, University of Illinois, and Paul Weatherwax, Indiana University, for their critical reading of his manuscript but is especially indebted to Dr. P. Maheshwari, Dacca University, Dacca, India, for his valuable suggestions and comments.

"ANTH.–TAP. (amoeboid); DIV. OF P.M.C. (succ.); P. (3-nucl.); OVULE (2-integ.; anat.); PAR. CELL (absent); E.S. (*Allium* T.); END. (*He.* or *Nu.* T.); EMB. (*Sag.* T.)."

"Put in plain English this means that the anther tapetum is of the amoeboid type; the divisions of the pollen mother-cells are successive; the pollen grains are 3-nucleate at the time of shedding; the ovule is anatropous and has two integuments; no wall cell is cut off by the primary archesporial cell which functions directly as the megaspore-mother-cell; the embryo-sac development is of the *Allium* type; the endosperm is of the *Nuclear* or *Helobiales* type; and the embryo is of the *Sagittaria* type" (loc. cit., p. 32).

Fully aware of the possibility of greater condensation Maheshwari expressed the hope that a list of internationally acceptable symbols be developed and used both by students of plant embryology and classification. In the light of the great value generally attributed to "floral formulas" in discussions of plant relationships and in teaching plant taxonomy, the following list of symbols is tentatively proposed and their applicability demonstrated in several cases.

Other systems of annotation proposed solely for the characterization of the various types of development of embryo sacs, namely those of Chiarugi, Radermacher, Rutgers (summary in Schnarf 1929), and Fagerlind (1944) are not incorporated here, because of their detailed nature and the lack of complete agreement regarding the best method of designating the known types of embryo sac development. They are, however, very well suited for the careful description of embryo sac development, notably Fagerlind's last scheme.

At present only those sets of characters are included in the following list whose taxonomic usefulness has by now been established beyond doubt. As is most likely, other characters will be found in the future and suitable symbols for these can readily be added to the present list. The selected characters are those given by Schnarf (1931, 1933) and amended by Maheshwari (1945). The designations of the types of embryo sac development follow Maheshwari (1941).

T = anther tapetum Tg = glandular Ta = amoeboid Tp = tapetal plasmodium.
P = pollen; Psi = quadripartition of microspore mother cell by furrowing (simultaneous).
Psu = quadripartition of microspore mother cell by cell plates (successive).
/2 = two nuclei in pollen grain at time of discharge from anther, /3 = three, etc.
Ov = ovule; (Ov) = unitegmic (one integument), ((Ov)) = bitegmic (two integuments).
Ti = integumentary tapetum.

Ov = integument absent. ob = obturator.
c = crassinucellate t = tenuinucellate.
$\overline{\text{Ov}}$ = orthotropous $\underline{\text{Ov}}$ = anatropous $\text{O}\hat{\text{v}}$ = campylotropous.
My = micropyle My/i = formed by inner integument My/o = by the outer integument My/2 = formed by both integuments.
Nu = nucellus Nu^{t} = integument begins near apex of nucellus Nu_{t} = near base.
hy = hypostase. Nu+ = nucellus with long beak-like process in micropyle.
Ar = archesporium one-celled $\text{Ar}\infty$ = many-celled.
θ = parietal cell absent. ! = parietal cell present.
ES = embryo sac ESn = normal type ESoe = Oenothera type ESal = Allium type ESpp = Peperomia pellucida type ESph = Peperomia hispidula type ESg = Gunnera type ESpe = Penaea type ESpy = Pyrethrum type ESd = Drusa type ESac = Acalypha type ESf = Fritillaria type ESpa = Plumbagella type ESpo = Plumbago type ESad = Adoxa type.
S = syngamy po = porogamy ch = chalazogamy + = long interval between pollination and fertilization, exceeding one week.
E = endosperm Enu = nuclear Ece = cellular Ehe = Helobiales type Ehe/nu = Heliobiales or nuclear type.
Eh/m = micropylar Eh/c = chalazal Eh/m + c = micropylar and chalazal endosperm haustoria.
Em = embryo Emp = Piperad type Ema = Asterad type Emca = Caryophyllad type Ems = Solanad type Emo = Onagrad type Emch = Chenopodiad type Emsag = Sagittaria type.[2]
su = suspensor haustorium.
Ap = apomixis. Py = polyembryony. Pa = parthenogenesis.

Using these symbols the embryological formula of the Alismaceae reads as follows:

Ta, Psu/3, (($\underline{\text{Ov}}$))θ, ESal, Ehe/nu, Emsag.

The floral formula (Pool 1941, p. 101) by comparison reads:

$$\frac{\text{CA}^{3}\text{Co}^{3}\text{S}^{6-\infty}\text{P}^{6-\infty}}{\text{PfMoDiAch}}.$$

The species (3) of the aquatic genus *Trapa* have long been considered members of the family *Onagraceae* (Oenotheraceae). When it was found that the development of the embryo sac in this genus follows the normal type and that a well developed suspensor haustorium is present, it seemed even more out of place than it had been for other reasons, i.e., fruit. The embryological formula of the separate family established for this genus, the *Hydrocaryaceae* Raimann (Engler & Diels 1936) or *Trapaceae* (Pulle 1938), is as follows:

((Ov))c, Ar!, ESn, Em/su.

The embryological formula for the Onagraceae reads:

Tg, Ps/2, ((Ov))c, Ar!—Ar^{∞}, ESoe, Spo, Enu, Emo.

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[2] Although Johansen (1945) points out that no essential differences exist in the embryogeny of the Dicotyledones and that of the Monocotyledones, it may be desirable to distinguish different types of embryo development in these groups, at least in view of the profound differences in later stages and seedling structure.

Obviously the life history of the Onagraceae is better known than that of the genus *Trapa,* a situation which accounts for the comparative brevity of the embryological formula of the genus *Trapa* as compared with that of the family Onagraceae. But it is evident that the removal of *Trapa* is justifiable on these as well as other grounds.

The position of the family *Cactaceae,*'Order Cactales according to Bessey *et al.*, and its possible affinities have long been problematic. Hutchinson (1926) and Bessey (Pool 1941) placed it near the Cucurbitales, whereas Wettstein (1935) inserted it between the Aizoaceae and Portulacaceae. It must be remembered, however, that the order Centrospermae sensu Wettstein includes approximately the same families as Bessey's order Caryophyllales except the Salicaceae. To show the differences between the Cucurbitaceae and Cactaceae their respective embryological formulas have been determined and are herewith presented:

Cactaceae: Tg, Psi/3, $((O\hat{v}))c$, Myi, Ar!, ESn, S+, Enu.

Cucurbitaceae: Tg, Psi/2, $((\underline{Ov}))c$, Nu+, Ar!, ESn, Enu, Ap (?).

Several important characters can not be indicated in these formulas. The Cactaceae have a cavity in the chalazal part of the ovule between the two integuments and sometimes also between the inner integument and the nucellus. This cavity occurs in various families belonging to the Centrospermae. The Cucurbitaceae on the other hand develop a nucellus with a long, beak-like process extending into and often through the micropyle, here indicated as Nu+. The pollen tube develops characteristic haustoria which destroy the nucellar process in the micropyle. Morphological, anatomical, and chemical evidence supports the embryological similarity between the Cactaceae and Aizoaceae as well as other families of Centrospermae (Gibbs 1945).

Other instances of the applicability of embryological data in critical cases have been recorded and could readily be illustrated by the embryological formulas based on them (Maheshwari 1945; Mauritzon 1939; Schnarf 1933, 1937). Notable examples are the Liliaceae in the conventional sense and their modern segregates, the large order Synandrae (Campanulaceae, Lobeliaceae, Goodeniaceae, Compositae) and many others. The accepted orders of flowering plants may well be delimited differently, if embryological data are applied consistently, and groups which have so far not been investigated are studied embryologically. Therefore, the use of embryological data will be greatest as supplementary evidence in the improvement of our systems of classification, particularly with regard to the determination of the correct position and affinities of families and orders, whereas their application in purely descriptive works such as floras and manuals as well as in teaching elementary plant taxonomy may never prove feasible.

Embryological data need not be accorded more recognition than other taxonomically valuable characters. They do, however, deserve their rightful place among the others, a position they have not yet attained in the eyes of all botanists.

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SIERRA TACUICHAMONA—A SINALOA PLANT LOCALE

HOWARD SCOTT GENTRY

In mid-Sinaloa Sierra Tacuichamona stands 4000 feet or more above the narrow coastal plain not far from the sea (fig. 1). It is volcanic in origin with a high central massif of brecciated lava flanked by rather deeply dissected ridges in considerable intricacy. Because of its stage of physiographic development and its structural similarity to neighboring mountains, its origin can be placed contemporaneously with the general foothill complex of northwestern Mexico, which arose at sometime in the Upper Tertiary. The whole is dynamically linked with the great Sierra Madre Occidental.

The great bulk of the mountain is covered with a climax virgin Short-tree Forest, persisting through 3000 or more feet of elevation. The general stature of the forest dominants is 35 to 40 feet. The spacing is regular and in the piedmont usually allows freedom of movement without a machete, while in the higher interior gradients a machete is often necessary. This forest as a whole is more tropical and expansive than the Short-tree Forest of the Rio Mayo to the north. The greater prevalence of epiphytes and indeed the whole tropical element appear engendered by the proximity of the ocean with its moist breezes.

Oak Forest occupies the summits and the higher slopes on the east in a rain shadow of the lee side (fig. 2). Its aspect is more arid than the Short-tree Forest. Oak Forest is an open broken member occupying elevations from 2000 to 4000 feet. Expanses of harsh-leaved grasses occur as well as numerous shrub populations, dispersed or in thickets. The leaf generally from grasses to composites is tough and scabrous and springs from a rocky shallow calcareous soil.

Savanilla is limited to a small area between the oaks and the Short-tree Forest on the north end of the mountain. This is an open formation on mild slopes with patches of trees and shrubs dispersed through turf-like grassland.

Thorn Forest and Pine Forest are both lacking. There is too much rainfall for the former. The lack of any appreciable highland appears to limit the pines to a few small clumps near the summits.

An interesting fauna accompanies this plant rich wilderness. Mountain lions and jaguars (*liones y tigres* to the natives) pad through the great canyons killing deer and cattle, and frightening men and their horses. Peccaries scuttle through the underbrush. Cholugos, *Nasua narica*, the long-nosed relative of the racoon, climb cliffs and trees, getting a relatively luxurious living from the wealth of roots and fruits. Among the many indigenous birds are parrots, chanates, and two pheasant-like birds, the chachalaca and the much rarer "el faisan."

The Piedmont Forest. The plain around the west base of the mountain is covered with a uniform Short-tree Forest about 30 feet high. The trees are evenly spaced, and except for the light secondary covering of spindling undershrubs, one has little difficulty in walking where he pleases. In mid-February when we passed through, the amapa, *Tabebuia palmeri*, was through flowering, long seed-pods hung from their leafless branches. The most conspicuous flowers were the strong bright yellows of *Cassia biflora* and *tecomosuche*, *Cochlospermum vitifolium*, the white of confite, *Lantana*

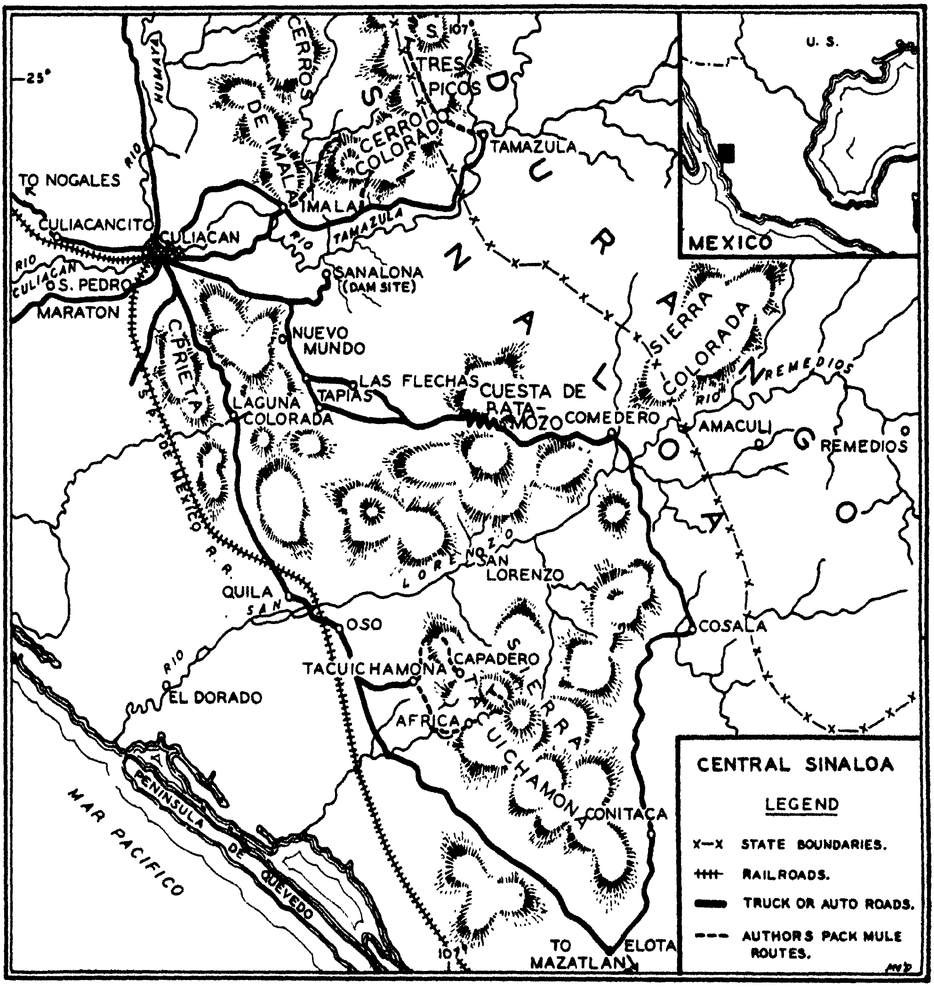

FIG. 1. Central Sinaloa, including Sierra Tacuichamona. 1: 250,000.

velutina, and the yellow-orange of *Lantana horrida.* Blooming then also but in less profusion were the cuajolote, *Bombax palmeri,* its huge white stamens standing out spread in the sun, the red-flowering vine compio, *Combretum farinosum,* a few palo santos, *Ipomoea arborescens,* still weekly putting out their white stars, and bacari, *Montanoa* sp. The vegetation was still rather green, for, following the winter rains, many of the trees and shrubs had put out new leaves or had been able to hold over those they had borne in summer. But many were too irrevocably bound to their habit of winter defoliation to respond. Noting the condition of the trees and shrubs as we traveled along we compiled a simple table as follows:

Responding with leaf	Holding over summer leaf	Not responding
Acacia cymbispina	*Lysiloma divaricatum*	*Ipomoea arborescens*
Croton fragilis (xeric form)	*Pithecolobium sonorae* (normal)	*Bombax palmeri*
Haematoxylon brasiletto	*Coutarea latiflora*	*Bombax* "batoco"
Cassia biflora	*Cordia alliodora*	*Cochlospermum vitifolium*
Caesalpinia platyloba	*Acacia pennatula*	*Conzattia sericea*
C. caladenia (xeric form)	*Cassia emarginata*	*Tabebuia palmeri*
C. eriostachys	*Randia* spp. (normal)	*Tabebuia chrysantha*
C. sclerocarpa (feebly)	*Guasuma ulmifolia*	*Bursera* spp.
Acacia farnesiana	"Isa" (feebly)	*Marsdenia* sp.
Bursera laxiflora		*Manihot* sp.
Cassia emarginata (feebly)		*Pereskia* sp.
Acacia cornigera		*Pedilanthus rubescens*
Crataeva palmeri (feebly)		
Prosopis spp.		
Pithecolobium tortum		
Euphorbia aff. *tresmariae*		
Mimosa palmeri		
Solanum amozonium		
Malva spp.		
Chlorophora tinctoria		

The Canyon Forest. Within the canyons the forest deepens and slope and narrow canyon bottom alike, except for arroyo beds, are bountifully covered with a delightful virgin forest. The axeman and bark-stripper have scarcely touched it, and we can suppose that this same forest has stood since Pleistocene times just about as it does now. From time to time the trail leaves the wash-bed of the Quebrada de Ilama and enters the slopes running under shady trees. During the summer rains when leaf is rampant the shade must be dense. Epiphytes are common upon the trees; orchids, *Tillandsia,* and a large coarse member of the Bromeliaceae. Lianas swing like huge, gnarled, and poorly twisted ropes from ground to limb, among them occasionally the perverted scandent form of *Pisonia capitata.* In places the canyon widens in the bottom and allows a "bottom-land" climax forest of unusual size and beauty. Its stature may reach 50 or 60 feet with isa, pochote, *Ceiba acuminata,* jauhuica, *Bursera arborescea,* manuta, *Lysiloma divaricatum,* and areyan, *Psidium sartorianum,* the principal dominants. Jauhuica is a splendid tree branched only in the crown with its thick smooth branches bearing out a heavy spread of foliage mostly above the rest of the trees. Hecho, *Pachycereus pecten-aboriginum,* in such woods is successfully established, but less dominant than on the Coastal Plains, for the best it can do here is to elongate to something over half the general forest stature.

The Cliff Vegetation. On the rock outcroppings and cliffs the forest species still persist but thin out to make way for more xeric types, such as *Bombax* spp., *Cochlospermum vitifolium, Plumeria rubra, Agave* spp., *Ficus* spp., *Hechtia,* and an elephantine prostrate vulgarly called "inche huevos." On cool shady rocks occur a new *Hofmeisteria,* a *Dyospiros, Lysiloma watsoni, Lemaireocereus, Bursera* spp., ferns, *Euphorbia* aff. *tres-mariae,* and a legion of others less frequently occurring.

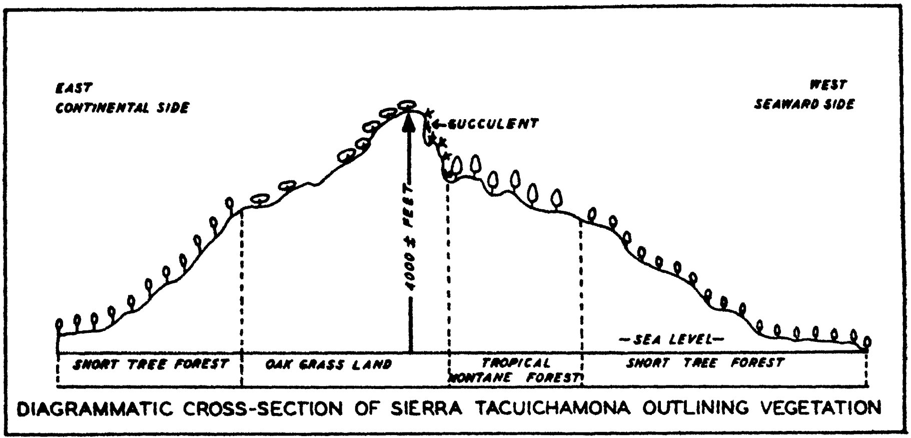

FIG. 2. Diagrammatic cross section of Sierra Tacuichamona outlining the vegetation.

Some Dominant Colonies. Near Rancho Africa, lying in the western canyons, a few species of trees form nearly pure stands or at the least are single dominants in such areas. The Mauutal[1] occupies hill swales with a stature of about 40 feet with trees well spaced, the sapling straight, elongate, and the undershrubbery very scant. The Apomal is a grove of magnificent tall slender trees, suggesting *eucalyptus,* about 70 feet high, branched only in a high crown holding heavy dark green foliage. It forms a clear open forest with scant undershrubbery. In the deep and usually steep-floored canyons these apomos, *Brosimum alicastrum,* form a dense shade. In such gloomy rocky glades grow only a few species of tropical shade-tolerant species; elongated, mesophytic perennial acanthaceous shrubs or herbs, the stinging huge-leaved *Urera caracasana,* the shrub *Phenax hirtus,* a few ferns, an entirely unexpected palm, *Chamaedorea*, and the attenuated otatillo rodillo, *Chusquea liebmanii*, whose graceful bamboo-like stems bend out in arcs 10 feet high or trail on other plants. *C. liebmanii* is here a remarkable northern extension in the previously known range of the genus. Epiphytic orchids are abundant on tree limbs. Often mixed with the apomos are a few other species of large trees, as juahuica, *Ficus*, *Prunus cortopico*, and bebelama de la Sierra.

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[1] Stand of Mauuta trees, *Lysiloma divaricatum.* Native idiom provides names for many tree colonies by adding the suffix, *al* (or *l*). As ecologic terms they are very handy and can seldom be improved.

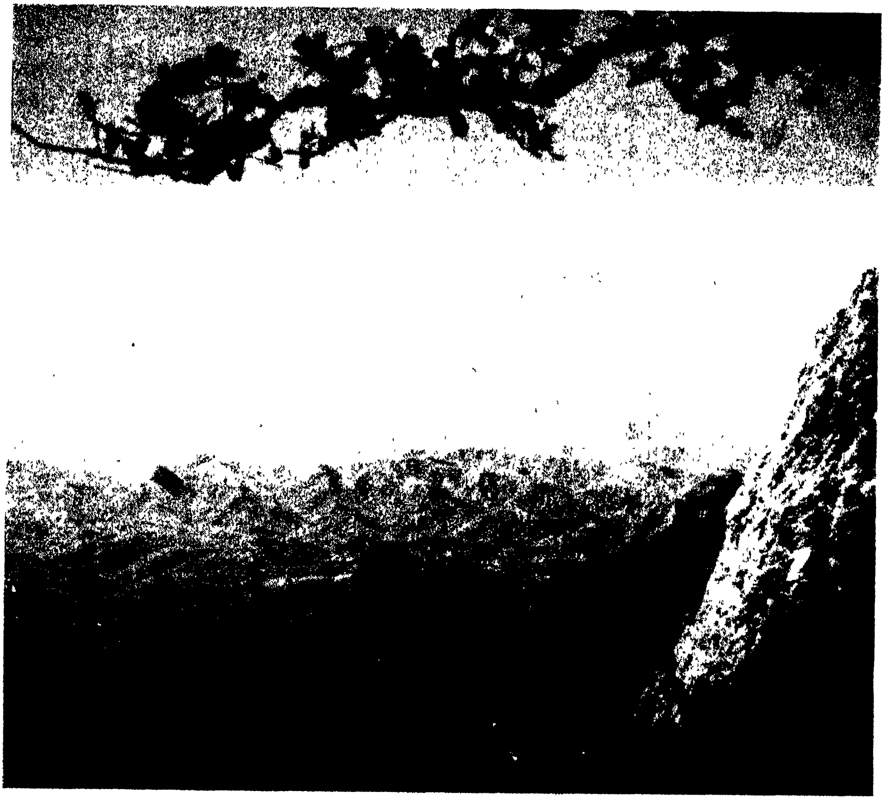

FIG. 3. View from the summit of Sierra Tacuichamona looking west to the Pacific Ocean, February 1941. Light patches draped on the hill summits are Oak Grassland.

Slope Forest. Shrubbery is exceptionally prevalent upon the slopes of the Rancho Africa. This is partly due to the presence of abandoned milpas, where shrubbery forms the adventive growth, and partly to a thinning of forest trees upon the steep talus slopes that have little soil. Particularly noted was a miscellany of broad-leaved shrubs, as *Montanoa patens*, *Lantana* spp., *Urera caracasana*, *Justicia salviaeflora*, other acanthaceous spp., and the shrub *Bouvardia bouvardioides*, whose stems when cut emitted a repulsive odor. But the real subdominants upon the broken lava slopes were stands of otate, *Arundinaria longifolia*, and under the trees *Chusquea liebmanii.* The latter bears hooks around the prominent nodes, which raked across our limbs and throats. Otate forms pure stands utilizing large areas upon the slopes and is also commonly mixed with the shrubs in open clumps under the trees. On the south slopes the more markedly drought-deciduous species prevail, with the heavy-limbed *Bursera* species, *Ceiba acuminata*, *Bombax pameri*, cacalosuche, *Plumeria rubra*, etc. There is less undergrowth. The whole formation usually continues to almost the full height of the mountain or to the foot of the last or highest volcanic rim. Northern slopes are greener with more grasses and *Chamaedorea* commonly forms small clumps among the rocks in the shade. This north-slope forest merges more quickly with the lower vanguard of the oaks.

Summit Vegetation. The top of the sierra is no more than a broken ridge sheared on every hand by high cliffs. Underbrush and large coarse grasses are rampant, which together with the broken terrain make walking difficult. Oaks are the prevailing trees, with a few small patches of pines confined to some steep northern slopes that I never succeeded in reaching. The underbrush of the mountain top, partly composed of oak rejuvenations, is largely due to the burning of the grass by the natives in the spring dry season.

Oak Forest. The dominant type of leaf in the Oak Forest is harsh; coriaceous to seabrous. The oaks themselves, the shrubs, the grasses, and even many herbs show this same character. In general throughout the Oak Forest of Western Mexico the scabrous leaf becomes, by its incessant repetition in myriad variation through many plant families, of singular interest. This leaf responds slowly to winter rains, as though reluctant to risk a few drops of guarded moisture in a transitory growth, when soon there is the long severe drought of spring to survive. There is on the whole much less Oak Forest on Sierra Tacuichamona than one would expect. The south and west areas have only a little, which is confined to small mesas and hill tops. Ill-defined remnants exist upon north exposures. East of the divide or axis, over the lower lying hills and slopes, is the best development. A scattered grove of *Erythea aculeata* was observed in that area upon a southern slope, and *Sabal rosei* grows indiscriminately upon slope and cliff and in draws.

On the northern end of the sierra around Capadero a great deal of the oak belt is occupied by harsh-leaved grasses, dominated principally by *Muhlenbergia emersleyi*, *Tripsacum lanceolatum*, and *Andropogon* and *Heteropogon* species. *Tripsacum lanceolatum* is most dominant upon the steeper slopes and the large breast-high clumps with cutting leaf-edges are serious impediments to travel. Occasionally there are stands of clumps of sacate aparejo, *Muhlenbergia gracilis* (?). The oaks are most successful on the moist shady slopes and are accompanied by a variety of shrubs, which occasionally form thickets, all, it may be repeated, with a marked tendency to be scabrous. *Quercus albocincta*, *Quercus tuberculata*, *Quercus chihuahuensis*, and a black oak with narrow shiny leaves, *Quercus gentryi*, make up the oak family. *Bombax palmeri* from the lower cerros persists upon the arid rock rims. In the canyons many of the mesic trees and shrubs march up above the lower oaks. Over the volcanic bedrock the soil is shallow. It is mixed with broken rock and litter on the slopes. On the mesas it runs to clay. Generally it is calcareous from the leachings and metamorphism of original limestone.

Savanilla. Below the oaks, where they intergrade with Short-tree Forest trees on the north side of the mountain, is a brief expanse of Savanilla. This is a low group-dispersed formation with patches of shrubs and trees alternating with open areas of turf-like grasses, as *Bouteloua eludens* and *Cathesticum species*. The arborescent species are drawn from neighboring forest elements and make up heterogeneous mixtures, as oaks from Oak Forest, *Lysiloma divaricatum* and *Tabebuia palmeri* from Short-tree Forest. Common to this locality of Savanilla were also; *Mimosa palmeri*, *Lemaireoccreus* sp., *Byrsonima crassifolia*, *Psidium molle*, and *Dodonea viscosa*, shrub Compositae, and many others. A single plant of *Fouquieria macdougali* established a southern record for the species. It is a singular habitat with a rich flora, better exampled in other localities and will be described in a later paper.

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NAJAS ARGUTA IN CENTRAL AMERICA AND ITS RELATIONSHIP TO N. WRIGHTIANA

ROBERT T. CLAUSEN

Humboldt, Bonpland and Kunth (Nov. Gen. & Sp. Plant. **1**: 298. 1815) described *Najas arguta* from Mompos in the drainage of the Magdalena River in Colombia, South America. In their description, they mentioned that the leaves are strongly toothed, but they had neither flowers nor fruits. Subsequently, Schumann, in Martius, Flora Brasiliensis **3**(3) : 729 (1894), described the flowers and seeds from Brazil. I have seen in the Gray Herbarium and at the New York Botanical Garden specimens collected from the Amazon

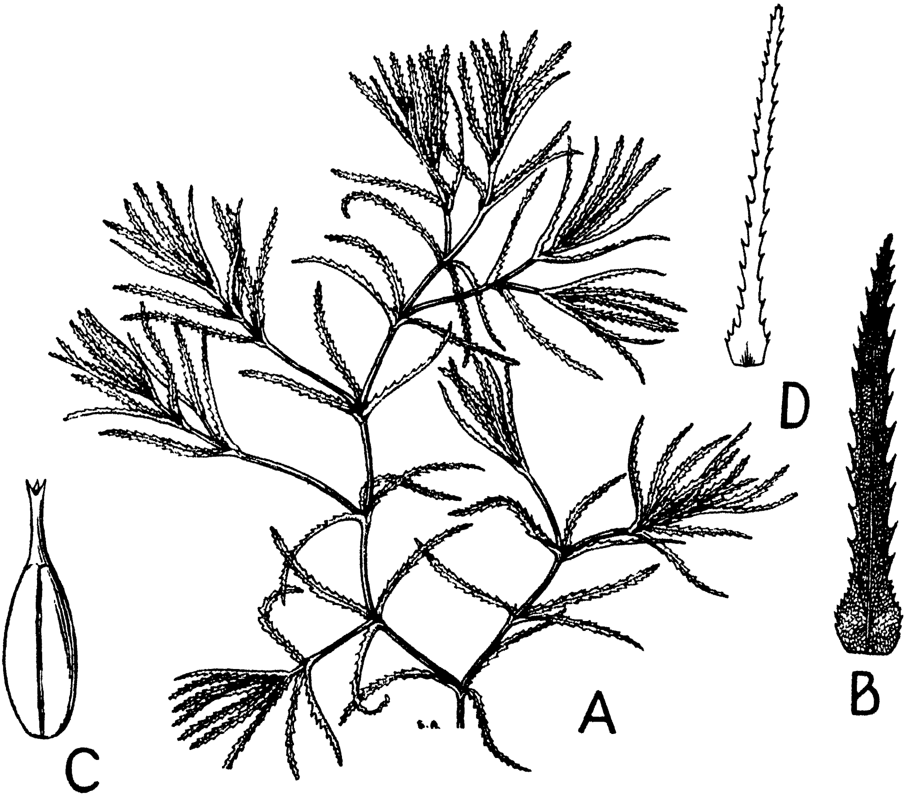

FIG. A. Habit sketch of *Najas arguta* from Chagres River at Las Guacas, Panama (× 1). FIG. B. Leaf of the same specimen (× 2.5). FIG. C. Staminate flower of the same (× 10). FIG. D. Leaf of *N. Wrightiana* subsp. *Wrightiana* from Cuba (× 2.5). Figs. A–C by Miss Elfriede Abbe and Fig. D by Miss Florence McKeel.

River in 1851 by Richard Spruce, no. 1622. This collection was cited by Schumann and agrees with the description of *N. arguta*. Also I have seen similar specimens from La Paila, Colombia, and others differing only in having narrower leaves, 0.6–0.8 mm. wide, from the Guayaquil River in Ecuador, *W. Jameson 544*. Specimens from Cuba identified as *N. arguta* are not that species. On the other hand, two collections from Panama are the same as South American *N. arguta* and constitute the northernmost and only known records for the species in Central America. F. C. Bishop collected it in Gatun Lake near the mouth of Gatun River, opposite Monte Lireo, on May 3, 1934. Lt. Harold Trapido, on April 5, 1945, collected, as no. B1021, many plants with staminate flowers in a backwater of the Chagres River at the mouth of the Rio Moja Polla near Las Guacas. According to Lt. Trapido, *N. arguta* is a dominant feature of the aquatic flora of the Chagres River and Gatun Lake; also it is the principal breeding place of *Anopheles albimanus*. Figures A–C, prepared from Trapido's collection, show some of the features of *N. arguta*. The stems are slender and the leaves 0.8–1 mm. wide, rarely less, with the teeth of the margins prominent, but shorter than the width of the blade from the base of the teeth on one side to the base of those on the other. The seeds of South American specimens are 2.5 mm. long.

The common *N. guadalupensis* (Spreng.) Magnus, which is widespread in tropical America, and extends northwards to the bays of the lower Great Lakes and Lake Champlain, is readily separated from *N. arguta* by its almost entire, very finely serrulate leaves and usually smaller seeds, 1–2.2 mm. long. *N. Wrightiana* A. Br. is less easy to distinguish, though the separation can be made as shown by the following key:

A. Seeds 2.5 mm. long; teeth of leaves much shorter than the width of the leaf *N. arguta.*
AA. Seeds 1–1.4 mm. long; teeth of the leaves almost as long as the width of the leaves *N. Wrightiana*

N. Wrightiana is known from Cuba, the coastal plain of Mexico north of the Isthmus of Tehuantepec, and the Yucatan Peninsula. Also it has been cited from South America, from Pernambuco in Brazil, but I have not seen specimens from there. The Yucatan population may be separated from that of Cuba and the Mexican coastal plain as a subspecies, though the differences are of a sort that indicate close relationship. The seeds of the two populations are similar, but the leaves differ primarily in the number of teeth along the margins and in width.

N. Wrightiana A. Br. subsp. **Wrightiana** (R. Br.) R. T. Clausen, comb. nov., based on *N. Wrightiana* A. Br., Sitzb. Ges. Naturf. Fr. Berl. p. 17 (1868). The distributional area of subsp. *Wrightiana*, as understood by me, is Cuba and the coastal plain of Mexico near Vera Cruz. A typical leaf from Cuba is shown in figure D.

N. Wrightiana A. Br. subsp. **multidentata** (Koch.) R. T. Clausen, comb. nov., based on *Naias multidentata* Koch, Ber. Schweiz. Bot. Gesell. **44**: 341 (1935). The type locality is "Forest Home," Punta Gorda, British Honduras, at an altitude of 61 m. The type, *W. A. Schipp 991,* is in the Herbier Delessert, Conservatoire Botanique de Genève. Isotypes are available in the herbarium at the New York Botanical Garden and at the University of Michigan. Other specimens of this subspecies have been collected at Uxmal, Yucatan, and Lake Peten in the Department of Peten, Guatemala. Plants from Lake Yaxha, Dept. of Peten, are more like subsp. *Wrightiana* and must be regarded as intermediate.

KEY TO THE SUBSPECIES OF NAJAS WRIGHTIANA

A. Leaves with 15–25 teeth on a margin, 0.4–0.6 mm. in width. *N. Wrightiana* subsp. *Wrightiana.*

AA. Leaves with 25–40 teeth on a margin, 0.5–0.9 mm. in width. *N. Wrightiana* subsp. *multidentata.*

I wish to express appreciation to Brother León of Havana, Cuba, for the loan of a valuable series of specimens of *Najas* from the Herbarium Savalle, Academia de Ciencias de la Habana, and from the Herbario del Colegio de La Salle, Vedado-Habana. This material has greatly aided my studies.

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NOTES ON TRIFOLIUM

JAMES S. MARTIN

T. GYMNOCARPON Nutt. In 1880, Watson described *Trifolium plummerae* from northwest Nevada. He made no reference to *T. gymnocarpon* Nutt. and may not have been aware of the close relationship. According to his description, *T. plummerae* differs from *T. gymnocarpon* chiefly by its small size. Lojacano recognized the species in 1883 and included the difference of pubescence in his description but he mistakenly credited the name to Lemmon. McDermott in 1910 reduced the entity to a form of *T. gymnocarpon* but made her distinction the same as had Watson. No author since this time seems to have recognized the entity in any form. The plants in question cannot be properly distinguished from typical *T. gymnocarpon* on the basis of size, leaf shape, flowers, etc., but can be easily distinguished on the basis of leaf pubescence. Brief descriptions, synonymy, and discussion of the two entities are given below.

The species most apt to be confused with *T. gymnocarpon* is *T. lemmonii* Watson, which has, in fact, been confused by McDermott (No. Am. Sp. Trif. 194. 1910). *T. gymnocarpon* is usually a much smaller plant than *T. lemmonii,* it always has fewer flowers, and the rachis is always short, has but one to four distant whorls of flowers, and is never swollen. The flowers are often reflexed but the curvature is all in the pedicels, the base of the flower being nearly straight. *T. lemmonii* always has reflexed flowers and a part of the curvature is in the base of the flower itself, and the rachis is long and bears many close whorls of flowers.

KEY TO THE VARIETIES OF T. GYMNOCARPON

Leaflets all glabrous above.	*T. gymnocarpon* var. *gymnocarpon.*
Leaflets mostly sparingly strigose above, rarely a few leaflets of the plant glabrous on the upper surface.	*T. gymnocarpon* var. *plummerae.*

T. GYMNOCARPON Nutt. var. **gymnocarpon** (Nutt.) Martin, var. nov. *T. gymnocarpon* Nutt. in T. & G., Fl. N. Am. **1**: 320. 1838. *T. subcaulescens* Gray, Ives Rep. Colo. River Bot. 10. 1860; TYPE, *J. S. Newberry,* in pine forest near Ft. Defiance, Arizona, May 22, 1858 (on type sheet date given as May 25; Gray Herb., isotype at N. Y. Bot. Gard.). *T. nemorale* Greene, Pittonia **4**: 136. 1900; TYPE, *C. F. Baker 446,* Los Pinos (Bayfield), Colorado, May 17, 1899 (isotypes at Univ. Calif. Gray Herb., Pomona Coll., N. Y. Bot. Gard., and New Mex. A. & M.). *T. gymnocarpon* Nutt. var. *subcaulescens* (Gray) Nelson, Man. Bot. Rocky Mts., 279. 1909.

Often subcaulescent, stems rarely up to 10 cm. long; leaflets glabrous and green above, sparingly to densely strigose and grey-green below. Flowering from April to June.

TYPE: *T. Nuttall,* "Dry hills of the Rocky Mt. Range, near the sources of the Sweetwater of the Platte," Wyoming (type at N. Y. Bot. Gard.; isotype at Gray Herb.).

Distribution: Southern Wyoming to northern Arizona and New Mexico, usually on dry hills and plains, 5500 to 9000 feet elevation.

Representative material: *C. F. Baker 161, 446; E. D. Merrill 601; A. Nelson 1230, 10205; R. C. Rollins 1669; F. Tweedy 4209; S. Watson 248.*

In the group here considered two entities have often been recognized, *T. gymnocarpon* and *T. subcaulescens.* There are some slight differences between these two. Plants from Wyoming (including the type of *T. gymnocarpon*) and central Utah usually have short flowers from 7.5 to 10 mm. long, while the flowers of plants from Colorado, New Mexico, and Arizona (including the type of *T. subcaulescens*) are mostly from 10 to 13 mm. long. To a slight extent, the amount of pubescence is correlated with the flower length. Northern plants are usually sparsely strigose, while southern plants are more thickly strigose, the most heavily pubescent plants being those from New Mexico. However, these characters do not appear to be sufficiently sharp to warrant recognition for the two entities.

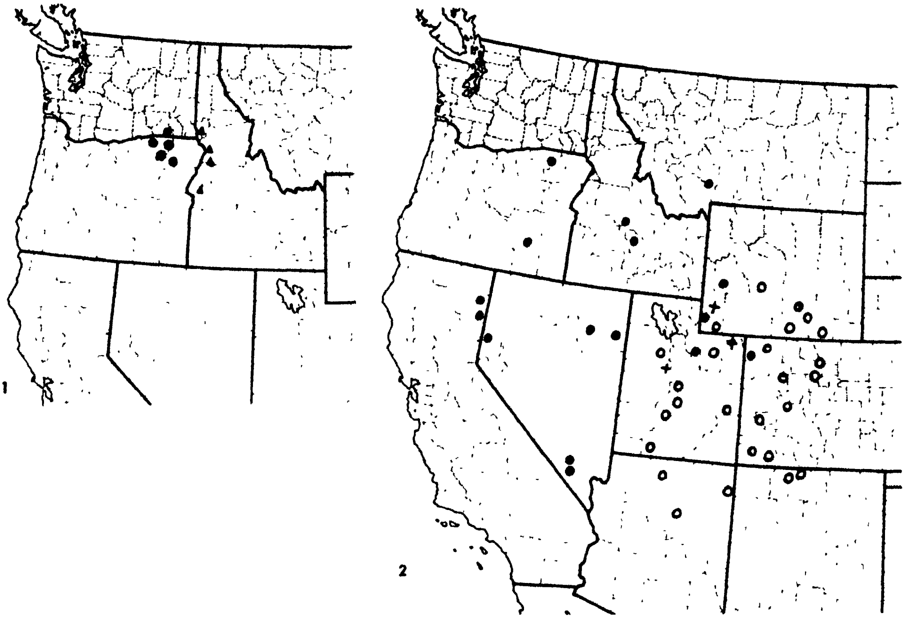

FIG. 1. Distribution of *T. plumosum*: dots, *T. plumosum* var. *plumosum*; triangles, *T. plumosum* var. *amplifolium*. FIG. 2. Distribution of *T. gymnocarpon*: circles, *T. gymnocarpon* var. *gymnocarpon*; solid dots, *T. gymnocarpon* var. *plummerae*; crosses, intermediates between these two varieties.

T. GYMNOCARPON Nutt. var. **plummerae** (Wats.) Martin, var. nov. *T. plummerae* Watson, Bot. Calif. **2**: 440. 1880. *T. plummeri* Lemmon ex Lojac. Nuov. Giorn. Bot. Ital. **15**: 162. 1883, based on the same type as the preceding, probably not intended as a new description and erroneously ascribed to Lemmon. *T. gymnocarpon* Nutt. f. *plummerae* (Wats.) McDerm. N. Am. Sp. Trif. 192. 1910.

More usually caespitose than the typical variety; leaflets strigose and grey-green below, lighter green and less densely (but always noticeably) strigose above. Flowering in May and June.

TYPE: *J. G. Lemmon & S. A. Plummer*, Peaks above Pyramid Lake, Nevada, May 15, 1879, elev. 6000 feet (Lemmon's name only on labels, letter with type sheet says Plummer assisted with the collecting; type at Gray Herb.; isotype at Univ. of Calif.).

Distribution: Northeastern Oregon to Sierra County, California; Elko and Clark Counties, Nevada; southwestern Montana and Idaho to northeastern Utah, mostly in open areas in arid woodlands, 4800 to 9500 feet elevation.

Representative material: *C. C. Bruce 2293; I. W. Clokey 7561, 7782, 7983; C. L. Hitchcock 8832, 9470; A. Nelson 4521, 9018; M. Peck 2325; R. H. Peebles 13956.*

The two varieties of *T. gymnocarpon* here recognized are separated on a character which is usually unreliable but in the present instance seems fairly clearly to distinguish the two groups. Most specimens of the two are either definitely glabrous or pubescent but in northern Utah and southwestern Wyoming, where the ranges of the two overlap, there are a few plants showing intermediate amounts of pubescence, most leaflets on a plant being completely glabrous while a few other leaflets will have some hairs on the upper surface.

T. PLUMOSUM Douglas. This species occupies a rather restricted range in northeastern Oregon and adjacent Washington and Idaho. The basing of any distinction in this genus on leaflet width alone is likely not to be taken too seriously. However, the present separation is solely on that character. While the number of specimens examined is not large, the difference in width of leaflets and the distinctive geographical separation on the two sides of the Snake River Canyon are thought to be sufficiently marked to merit some separation of the two groups of plants.

KEY TO THE VARIETIES OF T. PLUMOSUM

Leaflets of the basal leaves 2–5 (7) mm. wide, apices slender, acuminate, apiculate. *T. plumosum* var. *plumosum.*

Leaflets of the basal leaves (8) 9–16 mm. wide, apices broader, acute, apiculate. *T. plumosum* var. *amplifolium.*

T. PLUMOSUM Dougl. var. **plumosum** (Dougl.) Martin, var. nov. *T. plumosum* Dougl. in Hooker, Fl. Bor. Am. **1**: 130. 1840.

Leaflets mostly narrowly linear, usually folded, falcate, with slender acuminate apices, those of the basal leaves 2–5(7) mm. wide, of the upper leaves sometimes a little wider. Flowering in June and July.

Type: *D. Douglas*, Blue Mountains, Oregon or Washington (not seen).

Distribution: Walla Walla County, Washington, to Union County, Oregon, on dry sagebrush slopes and in open pine woods, 2000 to 4000 feet elevation.

Representative material: *W. C. Cusick 459, 2348, 3345; D. D. Keck 3585; W. R. Moore 162; M. E. Peck 7710, 10438, 17436.*

T. plumosum Dougl. var. **amplifolium** Martin, var. nov.

Leaflets broader, elliptical, often folded and falcate, those of the basal leaves 8–16 mm. wide, of the upper leaves sometimes slightly narrower, apices acute, but not slenderly acuminate. Flowering in June and July.

(Foliolae latiores, ellipticae, saepe complicatae et falcatae, foliolis foliorum inferiorum 8–16 mm. latis, foliorum superiorum aliquando leviter angustioribus; apicibus acutis, apiculatis, autem non graciliter acuminatis.)

Type: *Marcus E. Jones 6254*, Salmon Meadows, Washington County, Idaho, June 22, 1899, elevation 4000 feet (Herb. Pomona College no. 27373; isotypes at Univ. of California, Stanford Univ., N. Y. Bot. Gard., and Univ. of Washington).

Distribution: Nez Perce County to Washington County, Idaho, on dry sagebrush slopes, 2000 to 5000 feet elevation.

Representative material: *A. A. Heller 3398; L. F. Henderson 2729; G. N. Jones 4976; M. E. Jones, 6354; B. Maguire 17294; C. W. Sharsmith 5619.*

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THE EVALUATION OF SOME TAXONOMIC CHARACTERS OF CULTIVATED BRASSICA WITH A KEY TO SPECIES AND VARIETIES—II. THE KEY[1]

VON GEE SUN

DISCUSSION

The merging of *Brassica pekinensis* Rupr. with *B. chinensis* L. is in agreement with the botanical facts. Since the writer has found no hybrid vigor in the F_1 of *B. chinensis* var. *pandurata* Sun (siao-yu-tsai) × *B. pekinensis,* and no distinct morphological difference between these except in the foliar organs, *B. pekinensis* may reasonably be regarded as a race closely related to *B. chinensis.* Although Tsen and Lee (1942) pointed out seven important characters for differentiating these two species, it is the writer's opinion that most of them are of minor importance. For example, Tsen and Lee stated, first, that *B. chinensis* is biennial and *B. pekinensis* is annual; but the writer has observed in Meitan that when they are sown in the early fall or late summer, both become marketable in early winter and set seeds next spring. Secondly Tsen and Lee state that, given cool moist soil, *B. chinensis* tends to make a turnip-like root, while the root of *B. pekinensis* is normal; according to the writer's observation turnip-like roots are found only rarely in *B. chinensis,* being uncommon in all varieties. Thirdly, a few setose hairs on the ribs of *B. pekinensis* as compared with glabrousness of *B. chinensis* may be regarded as a minor difference, for *B. chinensis* var. *pandurata* also has a few setose hairs on the ribs and leaf-blade. Fourthly, head formation in *B. pekinensis,* though typical, is subject to environmental modification and is often artificially brought about. Tsen and Lee also noted in their paper that growers used to tie the outer leaves together with straw or other materials and bank the soil over the lower part of the plant in order to obtain solid heads. Fifthly, Tsen and Lee pointed out that *B. chinensis* is commonly grown in the South and *B. pekinensis* is mostly cultivated in the North. Though this statement is generally true. the writer has found that its cultivation is not uncommon in Chekiang, Szechuang, Kweichow, and Yunnan.

For these reasons the writer does not consider the above five points as taxonomically important. The only big difference between *B. pekinensis* and *B. chinensis* is found in their foliar organs. Tsen and Lee summarized the characters of *B. chinensis* as follows: blade large, light green to yellowish-green, heart leaves yellowish-white, thin, veiny, crinkled, undulate, and sometimes indistinctly and irregularly dentate, without distinct petiole but with a flat, whitened, long base, 2–8 cm. wide, margined by a wide, thin, notched or jagged wing. The writer is in full accord with the above statement and would call attention further to the foliar morphology of Meitan siao-yu-tsai (*B. chinensis* var. *pandurata*), which, in his opinion, may be regarded as an intermediate race between *B. chinensis* and *B. pekinensis*. In this connection, it may be important to remind oneself of the general botanical principle that the characters of reproductive organs are more significant than those of vegetative organs. Not only is the development of the latter subject to environmental changes, but the characters of reproductive parts are comparatively more stable than those of other parts.

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[1] The first part of this paper appeared in Bull. Torrey Club 73: 244–281.

The distinguishing characteristics of *B. alba* Rabenh. (*Sinapis alba* L.) should be emphasized. They are as follows: (1) number of chromosomes and size of pollen grains; (2) size and shape of silique; (3) number of seeds per silique; (4) shape and length of beak; (5) hairiness of silique and of the entire plant; and (6) the furrowed stem. Since in none of these characters does this species agree with any other species of this group, the writer finds it difficult to agree with those who suggest combining the two genera *Brassica* and *Sinapis*. The phylogenetic relation between *Sinapis alba* and the species of *Brassica* proper should be of great taxonomic importance. For a study of this problem interspecific crosses were made in 1943, *Sinapis alba* being used as a common parent; the writer failed to obtain a single true hybrid seed.

It is of interest to observe that there is a parallelism in many characters between *B. nigra* and *B. juncea*, between *B. nigra* and *B. carinata*, between *B. oleracea* and *B. carinata*, between *B. oleracea* and *B. napus*, between *B. chinensis* and *B. napus*, and between *B. chinensis* and *B. juncea*. *B. nigra* has sepals wide-spreading and silique 4-sided and closely appressed to the rachis, which is strongly reminiscent of those of *B. juncea* var. *orthocarpa*. *B. carinata* has the same 4-sided silique as *B. nigra*, and both have a very short beak. The inflorescence of *B. carinata* is extremely elongated and open at anthesis, i.e., the opened flowers or unopened buds are widely distributed on the rachis, which is the typical character of *B. oleracea*. Both *B. chinensis* and *B. napus* have a very long beak, clasping stem-leaves, and corymb-like inflorescence with the flowers clustered at the top. Both *B. chinensis* and *B. juncea* have corymb-like short infloresences with flowers clustered at the top, and small petals.

According to the experimental results of Morinaga and U, Brassica naturally falls into six groups. The writer accepted their suggestion at the beginning and tried to combine into a single species all varieties and species having the same chromosome number. After a critical examination of the present materials, he found this impossible. Although *B. campestris* var.

oleifera and *B. chinensis* var. *pandurata* both belong to the same 10-chromosome group, it is easy to recognize most of the important differences between the two races. For instance, *B. campestris* has glaucous-green, distinctly pubescent radical leaves, very small petals, a petal claw not abruptly constricted, and a short silique; while *B. chinensis* var. *pandurata* has non-glaucous light green leaves with but few setose hairs on the midrib or blade, petals rather large and orbicular with an abruptly constricted but very short claw, and a large and long silique.

By an inspection of the varieties within these two species, one can realize that the horticultural variation of turnip varieties within the European 10-chromosome group has never been found in China; and the large number of horticultural varieties within the oriental 10-chromosome group, such as wu-ta-tsai and hwang-ya-tsai, has never been found in the western Old World. It is clear that two secondary centers of species-formation of the 10-chromosome *Brassica* have been differentiated by ecological and geographical agencies. As Vavilov wrote in 1940, after many years of collective studies on the most important cultivated plants, aided by cytologists, geneticists, physiologists, anatomists, and immunologists, we are coming to the concept of a Linnean species as a definite, discrete, dynamic system differentiated into geographical and ecological types and sometimes comprising an enormous number of varieties.

In *Gossypium* the same principle suggests a similar taxonomic system. For example, both *G. herbaceum* L. and *G. arboreum* L. have 13 haploid chromosomes, but definite dissimilarities have been found between these two species; and *G. arboreum* is distributed mostly in the eastern part of Asia, while *G. herbaceum* is confined to the western part of Asia, Africa, and the eastern part of Europe. Both *G. hirsutum* L. and *G. barbadense* L. have 26 haploid chromosomes, but they also exhibit great dissimilarities, and *G. hirsutum* is distributed in Central and North America, while *G. barbadense* is confined to the West Indies and South America.

In accordance with the above statement, the writer suggests dividing the 10-chromosome *Brassica* into two geographical races, one oriental and the other western. The oriental race is distributed in China and Japan and should be known by the old name *B. chinensis.* The distribution of the western race is mainly in Europe and it should be known by the old name *B. campestris.*

KEY TO SPECIES AND VARIETIES OF BRASSICA

A. Silique short, 11–30 mm., the beak short, 2.87–3.60 mm. *See* AA, *p. 373,* and AAA, *p. 374.*

B. Stem and leaves of young seedlings densely pubescent, the mature plant prominently hispid-hairy, the inflorescence short at anthesis, the flowers clustered corymbosely, the petals very small (mean length 7.55–8.95 mm.), silique very small (mean length 11.02–11.20 mm.); seeds per silique 3–8 (mean 4.6–5.6). 1. *B. nigra* Koch.

BB. Plant glabrous; inflorescence elongated at anthesis; flowers and buds widely distributed on the rachis; flowers medium large, the petals 13.75–15.97 mm. long; silique medium small (mean length 29.3–30.05 mm.); seeds per silique 5–18 (mean 11.2–11.9). 2. *B. carinata* Braun.

AA. Silique long (mean length 48.55–71.4 mm.), not 4-sided; plant glaucous-blue or blue-green (varying to red in horticultural varieties); flowers medium to large, mean petal length 11.2–23.9 mm.; petals light yellow, ochroleucous, cream-yellow, or rarely white, long-tapering to narrow bases.

B. Inflorescence elongated at anthesis; flowers large, the mean petal length 20.8–23.9 mm., the sepals mostly firmly erect and not spreading, often somewhat saccate at the base; pollen small (mean length 32.96–37.01 μ); beak medium short (mean length 6.9–11.3 mm.); mostly with thickened edible parts.

C. Stem of the first year elongated.

D. Stem branched and leafy, the leaves long-petioled, those of some kinds curled. 3a. *B. oleracea* var. *acephala* DC.

DD. Stem unbranched, the axillary buds arrested and swollen, bearing in the axils little edible heads or "sprouts" about 2.5 cm. in diameter; leaves short and broad, about as broad as long, often with ear-like lobes at the base. 3b. *B. oleracea* var. *gemmifera* Zenker.

CC. Stem of the first year short.

D. Stem thickened and tuberlike above ground; leaves relatively small, thinner, those on the flowering stem slender-petioled. 3c. *B. oleracea* var. *gongyloides* L.

DD. Stem not thickened nor tuberlike.

E. Terminal bud arrested, forming a compact head; inflorescence not normally developed the first year; leaves large, often 30 cm. across, oblong-obovate to nearly circular, little if at all lobed at the base, the stem-leaves variously clasping. 3d. *B. oleracea* var. *capitata* L.

EE. Terminal bud not arrested; inflorescence partly developed the first year.

F. Inflorescence compressed, forming a compacted mass of short, thickened, colorless peduncles, pedicels, bracts, and undeveloped flowers; leaves long-oblong or elliptic, strongly ascending. 3e. *B. oleracea* var. *botrytis* L.

FF. Inflorescence not compacted, but grown for the thickened flower-shoots that arise from the leaf-axils, making a more or less open and variously aborted panicle. 3f. *B. oleracea* var. *italica* Plenck.

BB. Inflorescence short at anthesis, the flowers clustered corymbosely at the top; flowers medium large, the mean petal length 11.2–15.325 mm., the sepals not firmly erect but rather separating from the petals; pollen large (mean length 39.97–42.0 μ); young radical and heart leaves bearing a few translucent setae on the ribs.

C. Beak long (mean length 16–17.3 mm.); root neither tuberlike nor thickened, mostly in the form of a straight tap-root; radical leaves long-petioled, oblong-obovate with small lobes on the lower part; stem-leaves oblong-lanceolate, toothed and notched but seldom lobed, mostly clasping. 4a. *B. napus* var. *oleifera* F. & G.

CC. Beak medium short (mean length 11.2–11.7 mm.); root large and tuberlike with a neck, branching more or less from the lower sides; radical leaves similar to those of No. 4a; stem-leaves with a large terminal lobe with 1 or 2 pairs of smaller lobes at the base, and often leaf-fragments on the petiole-like contraction, commonly clasping. 4b. *B. napus* var. *napobrassica* (L.) Petr.

AAA. Silique medium to medium long (mean length 19.1–53.7 mm.); inflorescence short at anthesis, the flowers corymbosely clustered at the top; flowers medium small, the mean petal length 7.63–13.2 mm., the petals yellow or cream-yellow to cream-white.

B. Sepals separating from the petals; pollen small (mean length 32.4–39.92 μ); petals less prominently tapering; plant green, dark green, or light green to yellowish-green, occasionally purple, only thinly or not at all glaucous; leaves glabrous to more or less sparsely setose-hairy on the ribs or veins.

C. Plant mostly glaucous-green, distinctly pubescent, bearing translucent setae on ribs and leaf margin; cluster of radical leaves not greatly developed nor of long standing but spreading over the ground.

D. Root not enlarged nor tuberlike, usually shallow and branching and not forming a straight, developed tap-root; stem-leaves sessile, auriculate-clasping; basal and lower stem-leaves variously lyrate toward the base, having a long terminal lobe and several pairs of small lobes; often known as a weed.
5a. *B. campestris* var. *oleifera* E. & G.

DD. Root characteristically large, softish, tuberlike, without neck; radical leaves petioled, deeply cut into small lobes at the base, with a large terminal lobe above; stem-leaves mostly denticulate, variously clasping but not auriculate. 5b. *B. campestris* var. *rapifera* Metz.

CC. Plant green, occasionally purple, mostly non-glaucous, a few slightly glaucous; leaves glabrous to sparsely setose-hairy on the ribs or veins; cluster or radical leaves often greatly developed for domestic uses; leaves usually entire, occasionally with a few teeth along the base of the midrib.

D. Stem-leaves clasping.

E. Radical leaves broad, light green to yellowish-green, prominently winged along both sides of the midrib, sparsely covered with setose hairs on the under side of the midrib.

F. Radical leaves yellowish-green, crinkled, their petioles very broad, flat, tooth-winged; heart leaves deficient in chlorophyll, closely folded to form a compact head.
6a. *B. chinensis* var. *pekinensis* (Rupr.) Sun.

FF. Radical leaves light green or purple, neither crinkled nor deficient in chlorophyll, pandurate or fiddle-shaped to oblong-ovate, sometimes the lower part of the wing lobed or wanting, the petioles narrow and thin.
6b. *B. chinensis* var. *pandurata* Sun.

EE. Radical leaves not winged, glabrous, light to dark green, occasionally glossy or slightly glaucous, the petioles thick, broad, and succulent.

F. Radical leaves ovate to oblong-ovate, green to light green, the petioles white or greenish-white, standing upright from the ground. 6c. *B. chinensis* var. *communis* T. & L.

FF. Radical leaves numerous, well spread on the ground in a broad rosette 50 cm. in diameter, dark green, glaucous, curved outward to some extent, the blades broad-ovate or suborbicular in outline, distinctly marked with a number of veins, the petioles greenish-white, scarcely bearing leaf-fragments. 6d. *B. chinensis* var. *rosularis* T. & L.

FFF. Radical leaves shiny dark green, entire, glabrous, the petioles thick, broad, succulent, white or greenish-white, not winged, the blades orbicular, usually curved inward with a pair of small auriculate leaflets below, standing upright in the winter, but spreading over the ground before anthesis; petals creamy white. 6e. *B. chinensis* var. *albiflora* Sun.

DD. Stem-leaves non-clasping, long and narrow, sessile, with expanded base; radical leaves not prominently winged, long-oblanceolate, very slender, the midribs narrow and thin, the blades sometimes curved inward. 6f. *B. chinensis* var. *angustifolia* Sun.

BB. Sepals wide-spreading; pollen large (mean length 39.52–46.72 μ); petals prominently tapering toward the base; plant green or light green to yellowish-green, occasionally purple, only thinly or not at all glaucous; mature leaves glabrous; young leaves glabrous to more or less sparsely setose-hairy on ribs or veins; shape various; stem-leaves non-clasping.

C. Root oblong, plump, tuberlike, more or less cylindric, broad and truncate at both ends, with a well marked hypocotyl or neck at the upper part, a profusion of laterals widely diffused at the base; plant glaucous-green; leaf outline various; petioles short.
7a. *B. juncea* var. *megarrhiza* T. & L.

CC. Root not tuberlike.

D. Lower part of the stem thickened, shortened, the nodes and the base of the rudimentary petioles enlarged, swollen, forming a nodule-like or horn-like edible structure; leaves various.
7b. *B. juncea* var. *tsatsai* Mao.

DD. Lower part of the stem neither thickened nor shortened, no nodule-like structure developed.

E. Petioles of radical leaves short and stout.

F. Radical leaves strongly developed, the blade large and broad, usually 30–60 cm. long, more or less hairy when young, entire, angled, or with fine teeth along the margin, almost sessile, the lower part of the midrib broad, attaining 7.5 cm. or more in width, the blade obovate to oval in outline; upper stem-leaves oblong to lanceolate, usually sessile or tapering toward the base. 7c. *B. juncea* var. *rugosa* Bailey.

FF. Radical leaves strongly developed, the blade crisped, curled, and fringed. 7d. *B. juncea* var. *crispifolia* Bailey.

FFF. Radical leaves multifid into many linear or filiform lobes or shreds which conform to the veins.
7e. *B. juncea* var. *multisecta* Bailey.

EE. Petioles or midribs of the radical leaves long, narrow, and thin.

F. Radical leaves long and narrow, oblanceolate, obtuse; blades neither notched nor lobed but evenly dentate; very low-branched. 7f. *B. juncea* var. *oblanceolata* Sun.

FF. Leaves linear; upper stem-leaves almost without blades; terminal part of the radical leaves entire, the basal part variously notched; stem weak, branching low.
7g. *B. juncea* var. *linearifolia* Sun.

FFF. Radical leaves long-petioled; blades obovate to oval, prominently tapering toward the base, a large obtuse terminal lobe above and several small lobes on the lower part.

G. Mature silique standing away from the rachis at an angle of about 45°; branching medium to high.
7h. *B. juncea* var. *gracilis* T. & L.

GG. Mature silique erect, closely appressed to the rachis, forming an angle of about 15° with it; branching high (the lowest branch measured 96 cm. above ground).
7i. *B. juncea* var. *orthocarpa* Sun.

SUMMARY

A large number of morphological characters of different species of *Brassica* have been investigated and their taxonomic importance evaluated.

Parallelism in many characters between certain species has been pointed out. A revised key to the species and varieties is presented. The following species are recognized: *B. nigra* Koch, *B. carinata* Braun, *B. oleracea* L. (6 vars.), *B. napus* L. (2 vars.), *B. campestris* L. (2 vars.), *B. chinensis* L. (6 vars.), *B. juncea* Coss. (9 vars.). *Sinapis alba* L. is not considered a species of *Brassica. B. pekinensis* Rupr. is merged with *B. chinensis* L.

ADDENDUM

In the course of typing this paper, the writer has found the paper of Sabnis and Phatak (1935) on the classification of cultivated Indian mustards. These authors divide *B. juncea* into two races based on hairiness, and divide *B. campestris* also into two races based on the position of the silique on the rachis. Although the writer has not examined their material, some points should be emphasized after an inspection of their descriptions. I doubt whether the silique of *B. campestris* var. *erectisiliquosa* is as erect as that of *B. nigra;* otherwise the appressed-silique character will not be confined to the 8- and 18-chromosome species. Since there is no definite borderline between petal-claw and petal proper, I insist on including the claw in the length of the petal. Sabnis and Phatak determined the silique length by including beak and pedicel. Because the beak length varies in the different species used, the results obtained by Sabnis and Phatak fail to represent the true length of the silique proper.

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TORREYA

BOOK REVIEW

A Catalog of Illinois Algae. By Max E. Britton. i–viii, 1–177. Evanston: The Graduate School, Northwestern University. 1944. $3.00.

The botanical literature of the state of Illinois has been enriched by the contributions of some of the most active algologists in this country. A noteworthy first step, largely bibliographic, in summarizing to date the knowledge of Illinois algae obtained from both published and unpublished data, is presented in this book. The literature containing algological data is conveniently divided into five groups based on the type of investigation involved: taxonomic and floristic studies, general ecological and pollution studies, studies of algae as animal food supply, monographs and other comprehensive reports, miscellaneous papers. From this literature the information contained in the catalog was obtained. For the most part the scheme of classification found in G. M. Smith's "Freshwater Algae of the United States" is followed. The species are listed alphabetically within each group. Following the name of a species a reference is given indicating a modern authority for the validity of the species and furnishing a readily available means of finding modern descriptions and other information written, as far as possible, in the English language. There are 178 genera including 962 species, varieties and forms.

It is stated that plans are being made to extend this summary survey in subsequent reports to include descriptions, keys, illustrations and habitat analyses for the algal groups growing in Illinois. Algologists will look forward to these reports with great interest.—JEROME METZNER.

FIELD TRIP REPORTS

MARCH 24. THE NEW YORK BOTANICAL GARDEN. A study of three lines of fern descent was made, first from the literature available, through the courtesy of Miss Elizabeth Hall, Librarian, and followed by an examination of fossil forms in the paleobotanical collection in the basement of the Museum Building. The group then journeyed to the fern house in the conservatory range and continued the study by examining the living forms there. Mr. Milton Gallub, Horticulturist in the fern house, assisted and answered questions about fern propagation. Attendance 28. Leader, Mrs. Gladys P. Anderson.

The success of this trip has led to a suggestion for similar studies of other groups, particularly tropical plants during the winter months. If this sounds interesting please notify the field chairman and plans will be made.

MARCH 31. POINT PLEASANT, N. J. A beautiful spring day. Waterfowl scarce owing to their heading northward two weeks or so in advance because of mild weather. The blue-winged teal was the best bird of the day. Also observed were: pied-billed grebes, great blue heron, baldpate and scaup ducks, ospreys, coots, great black-backed, herring and ring-billed gulls, rusty blackbird and sharp-tailed sparrows. Total species 32. Attendance 12. Leader, David Fables.

APRIL 13. BOYCE THOMPSON INSTITUTE FOR PLANT RESEARCH, YONKERS, N. Y. The group first visited the research project on aeration of deep cultures for citric acid production. Controlled production of test flies and the testing of efficacy of substances for knock down and killing of flies was demonstrated. The means of testing fungicides and insecticides as plant sprays, and dusts were then considered. A greenhouse heated entirely by light, sunlight or artificial, was displayed with plants growing thriftily. The laboratory for research in the nature and structure of viruses had prepared a very interesting exhibit as had two laboratories where growth regulating substances are being studied. The tour of the laboratories ended in the seed research rooms. A time lapse, kodachrome movie of growth, notably the development and opening of flowers, was shown in the conference room. Leaders, Dr. Zimmerman and Dr. Arthur. Attendance 19.

APRIL 14. SOUTHFIELDS, N. Y. A walk over the Nurian and some other trails for lichens particularly. Over 70 species were recorded. No additional plants in flower were added to the list of last week. A rather copious amount of *Buxbaumia* was observed. Attendance 10. Leader, G. G. Nearing.

APRIL 21. WINDBEAM MT., MIDVALE, N. J., for lichens and fungi. "Only four of us turned out, religion getting the better of nature." Leader, G. G. Nearing.

APRIL 28. SUCCASUNNA, N. J. Joint outing with Mountain Lakes Garden Club, led by Mrs. E. H. Kocher. "*Helonias* in flower and an acre of the rare cuckoo flower, *Cardamine pratensis.*" Attendance 22. Our leader, G. G. Nearing.

APRIL 28. AUDUBON NATURE CENTER AND FAIRFIELD CONNECTICUT GARDEN. Weather was cloudless, cool and ideal for walking. A list of 21 birds was compiled in exploring 5 of the pleasant Trails provided. Eighty-seven plants were listed, with *Shortia galacifolia* providing the thrill of the day. Wild, cultivated, and naturalized species were given equal consideration. The Fairchild Connecticut Gardens have been taken over by the adjacent Audubon Nature Center and Mr. L. J. Bradley, of the Connecticut Botanical Society, has been made Director. His job for this year is to restore the Gardens. Mr. Bradley assisted in conducting the trip and invited us to return at any time.

Mr. William Schneider, Jr., has made an interesting comparison of this trip with that of two years ago. In 1944 the trip was on May 28, a month later. Twenty species of birds were listed yet the two lists have only seven species in common. We wonder if the group went out for exotics in 1944. Blue jays, crows, and robins, missing from that list, are such large birds! Leader, Mrs. Henrietta Dotson. Attendance 8.

NEWS NOTE

The privately owned and privately managed new Desmond arboretum at Newburgh, New York, temporarily closed during the war period, will from now on be open again, daily, free of charge, to interested visitors.

Those wishing to inspect this arboretum, which, among other attractions, has a lovely view of the Hudson River looking down through the Highlands of the Hudson toward West Point, can obtain permission by writing or calling at the office of New York State Senator Thomas C. Desmond, 94 Broadway, Newburgh, New York, or by getting in touch with Arboretum Superintendent Rudolph M. Nocker.

The arboretum, started in 1939, now contains 499 species of trees and shrubs. Senator Desmond is endeavouring to include in this arboretum all native American trees and shrubs which may prove hardy in the Newburgh, New York, climate, together with some of the more interesting or more ornamental foreign trees and shrubs.

PROCEEDINGS OF THE CLUB

Minutes of the Meeting of November 20, 1945. The regular meeting of the Torrey Botanical Club was called to order by President Seaver at the Brooklyn Botanic Garden at 3: 40 p.m. with 8 members and friends present. The minutes were approved as read.

There was no business and the meeting was turned over to Dr. A. H. Graves who spoke on the "Effects of an Unusual Spring." The speaker's abstract follows:

> "In the northeastern U. S. the unusually warm early spring of 1945, followed by a cold wet period, lasting well into May, was the primary cause of serious troubles with native and cultivated trees and shrubs. First, there was much winter killing, which we should prefer to call "spring scorch." Next, a late April frost killed many flowers and flower buds—in Massachusetts, 80–90 per cent of the flowers of all fruit trees were killed. Fortunately the New York City region and New Jersey escaped these killing frosts. Again, because of continued, soaking rains and low temperatures, there was much root suffocation, resulting in root rot. The symptoms of this trouble, in early May, were similar to those of spring scorch, but the primary cause was different. The Sycamore blight, induced by *Gnomonia veneta*, was unusually destructive, but fortunately was confined almost entirely to the native species—*Platanus occidentalis.*"

After discussion and questions the meeting was adjourned at 4: 30 for tea which was served by the Garden staff.

Respectfully submitted,
FRANCES E. WYNNE,
Recording Secretary

Minutes of the Meeting of December 4, 1945. The regular meeting of the Torrey Botanical Club was called to order by President Seaver at Columbia University at 8: 45 p.m. There were 35 members and friends present. The minutes were approved as read.

The scientific program of the evening consisted of a very interesting paper by Dr. R. S. deRopp, "Growth of Normal and Malignant Plant Tissues in Vitro." After considerable discussion, the meeting was adjourned for tea at 9: 30.

Respectfully submitted,
FRANCES E. WYNNE,
Recording Secretary

Minutes of the Meeting of December 19, 1945. The regular meeting of the Torrey Botanical Club was called to order by President Seaver at 3: 45 p.m. at the New York Botanical Garden with 15 members and guests present.

There were six persons elected to annual membership, one to associate membership, and four resignations were accepted with regret.

The scientific program of the afternoon was an illustrated paper by Dr. Aubrey W. Naylor, "Problems in Nitrogen Fixation." After discussion, the meeting adjourned for tea at 5: 00 p.m.

Respectfully submitted,
FRANCES E. WYNNE,
Recording Secretary

INDEX TO AMERICAN BOTANICAL LITERATURE

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MORPHOLOGY

(including anatomy, and cytology in part)

(See also under Genetics: **Schnack & Gonzolez; Stout;** under Mycology and Plant Pathology: **Brodie**)

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BULLETIN OF THE TORREY BOTANICAL CLUB
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HETEROKARYOSIS, MATING-TYPE FACTORS, AND SEXUAL REPRODUCTION IN NEUROSPORA

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INTRODUCTION

Dodge was the first to describe the experimental synthesis of heterokaryons in *Neurospora* (1942). He used "unisexual" lines of the homothallic species *N. tetrasperma* and found that vegetative heterokaryons, more vigorous than their constituent homokaryons, could be produced, whether the strains were of the same or different mating-types. In *Neurospora crassa* this is not the case. In this species, vigorous heterokaryons can readily be made from two mutants of the same mating-type (Beadle & Coonradt 1944, Sansome in press), but when two such mutants belonging to different mating-types are put together, no appreciable increase in vigor occurs. Beadle and Coonradt suggested that the lack of vegetative vigor in combinations of different mating-types may be due to the "tendency of the hyphae containing nuclei of the two sexes to form fruiting bodies (perithecia) rather than grow in the manner of strictly vegetative hyphae." However, there is no real evidence that vegetative heterokaryons can be formed from cultures of opposite mating-types. The experiments to be described in this paper were made to investigate this point on the suggestion of Dr. B. O. Dodge. The results are discussed in relation to the mating-type factors and sexual reproduction in *N. crassa* and *N. tetrasperma*.

MATERIALS

Preliminary experiments were made on a wild type perithecium-forming strain obtained from Dodge under the name *N. crassa*, "Abbott," and also on combinations involving two mutants which were very similar in appearance, namely the mutant "*crisp*" described by Lindegren (1936) and a new mutant "*star*" on the same chromosome as *crisp* and the mating-type factors. Further experiments were made on two pairs of mutants *X–8*, *X–9*, *X–10*, and *X–11*. These mutants were all obtained in the first place by X-radiation of microconidia of the *fluffy* strain. The mutants were then crossed with *wild type* and from the resulting ascospore cultures mutant cultures of *A* and *a* mating-types were selected. Mutants were chosen for their reduced growth-rate, since it was believed that this would favor the production of heterokaryons, and for their dissimilarity to each other.

X–8 and *X–9* were distinguished from *wild type* and *fluffy* by their greatly reduced growth-rates and special habit of branching, and they could

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be readily distinguished from each other because *X–9* showed clustered branching at the ends of the hyphae whereas *X–8* did not.

X–10 and *X–11* also showed reduced growth and characteristic branching. In plate cultures the growth was of a rather spreading colonial type. Both mutants had an intense pink coloration when exposed to the light. The *X–11* mutant gave a more reduced compact type of growth than *X–10*, as illustrated in figures 2 and 3.

EXPERIMENTS AND RESULTS

N. crassa, "Abbott." A mass transfer was made from the original tube which contained perithecia. Macroconidia, which are usually multinucleate, from this subculture were spread thinly on a plate of potato-dextrose agar. On germination, 30 single macroconidia were isolated into tubes of potato-dextrose agar. One of these failed to grow, the remaining 29 cultures did not form perithecia. When tested with *A* (Lindegren's –) and *a* (Lindegren's –) strains, these cultures all reacted as *a*, giving perithecia with the *A* strain but not with the *a* strain. This strain therefore gave no evidence of the perpetuation of vegetative "bisexual" heterokaryons. It seems that the *a* component of the original culture may be more vigorous than the *A* component, but the experiment would have to be repeated several times with similar results before this could be taken as established.

Crisp and Star Combinations. *Crisp a* and *star a* inoculated together gave cultures which are *wild type* in appearance and therefore, presumably, heterokaryons. *Crisp a* and *star A* were inoculated together many times, the cultures usually remaining mutant in appearance. On one occasion, however, the combination gave a culture which appeared to be of the *wild type*. Eighteen hyphal tip isolations were made from this culture and all were *wild type* in appearance. From one of these hyphal tip isolates, 40 macroconidial isolations were made, all of which were phenotypically *wild type*. It was thought therefore that this was a true heterokaryon involving *crisp a* and *star A* nuclei. However, 31 of the macroconidial isolates were tested with *A* and *a* strains and they all gave the *A* reaction only. This led to the suspicion that the apparent heterokaryosis was actually the result of a mutation in the *star A* nucleus causing it to give a mycelium of normal appearance. The mutated *star A* nucleus probably results in a more vigorous mycelium than that of *crisp*, thus accounting for the absence of *crisp* among the original hyphal tip isolates. This suspicion was verified by an examination of subcultures from the original *star* culture which also appeared normal, and by the results of crosses between the reverted *star* and normal. These gave some *star* segregants, indicating that either the mutation modifying *star* to normal was not a reversion at the *star* locus but was a change at a different locus modifying the expression of *star*, or that the reverted *star* strain used in the cross with normal was a heterokaryon containing some *star* nuclei. No evidence for the production of "bisexual" heterokaryons was obtained from these experiments.

Since macroconidial and ordinary hyphal tip isolations had given no evidence of heterokaryosis involving nuclei of opposite mating-type, it was determined to make hyphal tip isolations from outgrowths of young perithecia, following the method of Dodge (1935).

X–8 A and X–9 A Combinations. *X–8 A* and *X–9 A* gave a culture resembling that of standard *fluffy*. Twelve hyphal tip isolates were all *fluffy* in appearance. When uninucleate microconidia of two of these hyphal tip cultures were plated out and isolated, the following results were obtained. The first culture yielded 119 cultures of *X–8* type, 113 cultures of *X–9* type, and 1 normal. The second culture gave 131 cultures of *X–8* type, 205 cultures of *X–9* type, and 2 normal. The three exceptional normal cultures when subjected to microconidial analysis gave *X–8* : *X–9* types in the following ratios. 39 : 46, 26 : 23, and 8 : 33. They probably resulted from the accidental picking up of two germinating microspores at once or from the occurrence of an occasional binucleate spore. These experiments show that combinations of *X–8* and *X–9* mutants readily form vigorous heterokaryons, when they are of the same mating-type, *A*.

X–8 a and X–9 A Combinations. *X–8 a* was inoculated together with *X–9 A*, with no apparent increase in vigor. The culture was allowed to form perithecia. Individual perithecia were isolated, the pieces of adhering mycelium were removed from them, and they were transplanted to petri dishes. Hyphal tip isolations were made from the hyphae which had the appearance of growing out from these perithecia. Forty-eight such isolations were made, of which 18 proved to be of the *X–8* type and 30 of the *X–9* type. When tested with standard *A* and *a* strains, the *X–8* type gave only the *a* reaction and the *X–9* type only the *A* reaction.

This experiment was repeated but the cultures obtained from each perithecium were kept separate. Eight perithecia were analyzed, the number of isolates from the different perithecia being 6, 7, 8, 14, 14, 14, 17, and 27, respectively. All the cultures were of one type, namely the *X–9* type. This evidence indicates that hyphae of only one mating-type are concerned in the formation of individual perithecia. The fact that only one type of perithecium was found in the second experiment may possibly be due to the earlier selection of perithecia in the second experiment. It is possible that *X–8* tends to form perithecia later or less readily than *X–9*. This would be in accordance with the reduced vigor of *X–8*.

Combinations Involving X–10 and X–11. A further series of experiments was made in order to test the hypothesis suggested by the results of the last experiment, that perithecia are made up of hyphae of one mating-type only. For these experiments mutants *X–10* and *X–11* were used. Figure 1 shows tube cultures of *X–10 a*, *X–10 A*, *X–11 a*, (*X–10 a* + *X–11 a*), and (*X–10 A* + *X–11 a*). The cultures were all inoculated at the same time into tubes of potato-dextrose agar. The combination of *X–10 a* and *X–11 a* clearly shows heterokaryotic vigor, whereas no such effect is shown by the *X–10 A* + *X–11 a* combination.

The mutants *X–10 A* and *X–11 a* were then inoculated on to a petri dish of cornmeal agar, which is favorable for perithecium production. Two inoculations of *X–10 A* were made at one side of the petri dish and two of *X–11 a* at the other. The mutants grew separately until they met. Perithecia were formed at the line of junction and spread out about 1 cm. on either side of it.

Single perithecia were isolated as before and the pieces of adhering mycelium were carefully removed by using fine needles and washing on a slide in sterile physiological saline solution. The perithecia were then transplanted to plates of plain 3 per cent agar. The use of plain agar induces a thin spreading growth and so facilitates the removal of single hyphal tips. After two days the cultures developing from the perithecia were examined. They were seen to be of two distinct types, as illustrated in figures 2 and 3. One type of perithecium, taken from the *X–10* side of the culture, gives rise to a rather loose colony, the other, taken from the *X–11* side, to a very dense, compact type of colony. When two perithecia taken from opposite sides of the culture are put together, the hyphae appear to grow separately (figs. 4, 5).

Altogether 54 perithecia isolated proved to be of the *X–10* type and 28 of the *X–11* type. The greater number of perithecia of the *X–10* type as compared with the *X–11* type is probably to be correlated with the more vigorous, spreading habit of the *X–10* type as compared with the *X–11* type.

As a further test, 50 hyphal tip cultures were made from the *X–10* type of perithecium, 10 from each of 5 perithecia. Similarly, 50 cultures were made, 10 each from 5 perithecia of the *X–11* type. However, in this case the growth was too compact for single-tip cultures to be made, so small inoculum cultures were made instead. The 50 cultures from the *X–10* type of perithecium proved to be of *X–10* type in appearance and the 50 cultures from the *X–11* perithecia were of *X–11* type. None of these cultures had produced perithecia three months after inoculation.

A single tip from an *X–10* perithecium was inoculated together with a small inoculum from an *X–11* perithecium into each of 10 tubes. After 2 months, perithecia were found in 9 of these tubes. In the remaining tube, only the *X–11* type appeared to have grown.

Furthermore, eight cultures from each of 5 different perithecia of the *X–10* type, when tested with *A* and *a* strains, gave the *A* reaction only, while nine cultures from each of 5 different *X–11* perithecia gave the *a* reaction only.

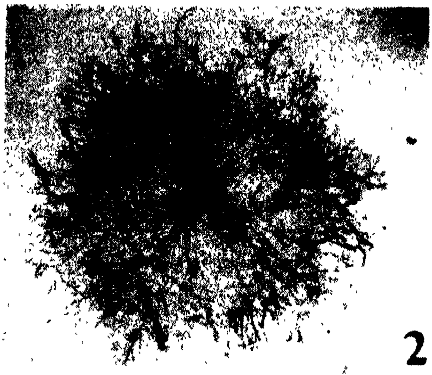
Thus cultures obtained from perithecia of the *X–10* type were all of the *X–10* type in appearance and "unisexual" of the *A* type. Cultures derived from perithecia of the *X–11* type were of the *X–11* type in appearance and "unisexual" of the *a* type.

DISCUSSION

All my attempts to obtain evidence of vegetative heterokaryosis involving *A* and *a* nuclei in *N. crassa* have failed. This is in accordance with the work of Dodge (1935) on *N. sitophila*, a closely related heterothallic species. Dodge transferred blocks of agar containing fertilized but immature perithecia to fresh agar plates and made hyphal tip isolations from the resulting cultures. One hundred and thirty-six such isolates produced no perithecia. He did not test them for mating-types. In the present experiments, heterokaryosis was favored by the use of mutants having a low growth-rate, which were known to give vigorous heterokaryons when of the same mating-type. Nevertheless no evidence of vegetative heterokaryosis involving nuclei of opposite mating-types could be obtained. Moreover, the results from the *X–10* and *X–11* cross, in which the perithecia of the two types could be distinguished (figs. 2, 3), indicate that mycelia of only one mating-type enter into the formation of the body wall of a single perithecium. We must conclude therefore that in the heterothallic species, the association of the two types of nuclei occurs in the ascogonium, probably by way of the trichogyne as described by Colson (1934), Dodge (1935), and Backus (1939). Vegetative "bisexual" heterokaryons cannot be readily induced in these species.

Contrasting Behavior of Heterothallic and "Homothallic" Species. In *N. crassa* and *N. sitophila* mating depends upon a pair of factors, the – or *A a* factors, which segregate at meiosis in the ascus. Meiosis is followed by a third mitotic division and as a result 8 ascospores are produced, 4 of type *A* and 4 of type *a*. In the secondarily "homothallic" species, *N. tetrasperma*, the *A a* factors are present and segregate at meiosis as in *N. crassa* but nuclei of the *A* and *a* type are associated in the young ascospore so that normally four "bisexual" spores are produced. "Heterothallic" lines which contain only one type of nucleus can be obtained by conidial isolations from the normal "homothallic" type.

As has been mentioned in the introduction Dodge (1942) produced vigorous heterokaryons in the "homothallic" species *N. tetrasperma*, whether he combined two lines of the same or of opposite mating-types. The fact that "bisexual" heterokaryons in *N. tetrasperma* may show heterokaryotic vigor renders less plausible the suggestion of Beadle and Coonradt (1944) that the lack of heterokaryotic vigor in "bisexual" combinations of *N. crassa* is due



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to a direction of the energies of the plant towards sexual reproduction rather than vegetative vigor. Dodge (1935) found that hyphal tip isolations made from outgrowths from small blocks of agar bearing young perithecia obtained by mating "unisexual" lines of *N. tetrasperma* were uniformly "bisexual." Although one can often isolate from such "bisexual" mycelia single tips which will be "unisexual," it seems that the difference between the so-called "homothallic" species and the heterothallic species of *Neurospora* is not merely a question of the mechanism of spore formation, but rather that nuclei of opposite mating-types are normally associated at all stages in the "homothallic" species, whereas in the heterothallic species they are kept apart until the time of sexual reproduction, as suggested by Dodge (1935).

"Bisexual" Heterokaryons in N. crassa. Lindegren (1934a) found that three out of five strains isolated from nature formed perithecia with both *A* and *a* strains, although they were self-sterile. These strains, which were of the conidial *wild type*, were crossed with tester strains of the *fluffy* type. A number of asci from these crosses were dissected and it was found that certain asci contained ascospores which gave rise to *wild type* and *fluffy* cultures in the expected 1:1 ratio, but other asci gave rise only to *wild type* cultures. The latter are supposed to be due to self-fertilization and are taken to indicate that the wild type is actually dikaryotic for the mating-type factors. This assumption is borne out by the fact that one "bisexual" strain showed somatic segregation, giving subcultures with one mating-type reaction only. Lindegren accounted for the self-sterility of the wild type cultures by assuming that they possessed genetic factors for heterokaryon self-sterility. Some support for this assumption is to be found in the results of combinations between some of the segregates from the original crosses. It was found that some of these combinations did not form perithecia, although known to be of opposite mating-types, because of their reaction with tester *A* and *a* lines. Lindegren suggests that "bisexual" heterokaryons arise in nature by the anastomosing of hyphae containing *A* nuclei with hyphae containing *a* nuclei and that in certain conditions natural selection will act in favor of self-sterile heterokaryons. The evidence of the present experiments

Explanation of figures 1–5

FIG. 1. 4-day cultures on potato-dextrose agar of *X–10 a*, *X–10 A*, *X–11 a*, (*X–10 a* + *X–11 a*), and (*X–10 A* + *X–11 a*). Heterokaryotic vigor is shown by the combination involving two mutants of the same mating type *a* but not by the combination involving mutants of different mating type. FIG. 2. 4-day colony from young perithecium of the *X–10* type. × 8. FIG. 3. 4-day colony from young perithecium of the *X–11* type. × 8. FIG. 4. 4-day colony from young perithecia of the *X–10* and *X–11* types. × 8. FIG. 5. Part of figure 4 showing the mycelia of *X–10* and *X–11* type growing side by side. × 25. Figures 2–4 were obtained by growing the colonies on cellophane strips (Fleming & Smith 1944) on plain agar, and mounting on microscope slides for photographing. Figure 5 was taken from the colony illustrated in figure 4 after it had been fixed in formal-acetic, stained with chlorazol black and mounted in gum chloral. Photograph and photomicrographs by E. Ashby.

and of the work of Köhler (1930) indicates that "bisexual" heterokaryons are not normally formed in this way. If the "bisexual" heterokaryons found by Lindegren originated by mycelial fusion they must have possessed factors permitting the vegetative association of *A* and *a* mycelia not present in the lines studied in these experiments. It is possible that these heterokaryons arose from "bisexual" spores. Lindegren (1934b) reported an exceptional ascus in *N. crassa* which had four large ascospores and four small "akaryotic" spores. The large spores gave rise to self-fertile cultures. Single conidial isolations were made from these cultures and, while most of these were "bisexual," some were "unisexual" as the result of somatic segregation. This somatic segregation proves that the cultures were heterokaryotic for the mating-type factors. Ascospores from self-fertilized perithecia gave heterothallic "unisexual" cultures.

Moreau and Moruzi (1932a, b, c) also obtained cultures from giant ascospores of *N. sitophila* which were "bisexual" and self-fertile. They do not report the occurrence of somatic segregation in these forms, but ascospores from the self-fertilized perithecia gave heterothallic cultures. The "bisexuality" in these instances also was almost certainly due to the fact that the cultures were heterokaryotic for the *A a* factors.

These "bisexual" heterokaryons arising in experimental material differ from the natural races investigated by Lindegren in being self-fertile. Since somatic segregation was observed in one case in which single conidia were isolated, it is possible that the fertility is due to a reaction between the heterokaryon and segregated homokaryotic mycelia. The author has also had some single-ascospore cultures which give both *A* and *a* reactions and appear to be heterokaryotic for these and other factors. These cultures form selfed perithecia but rather sporadically, as one would expect if perithecial formation is dependent upon the somatic segregation into one or other of the "unisexual" types.

Hormones and Sexual Reproduction in Neurospora. Moreau and Moruzi (1931) claim that perithecial formation in *N. sitophila* is caused by the stimulation of the mycelium of one mating-type by a hormone produced by the other mating-type and may be independent of the fusion of two nuclei of opposite mating-types. They inoculated one mating-type into one arm of a U-tube containing cornmeal agar and the opposite mating-type into the other arm. Ripe perithecia were produced in one arm of the tube and large sclerotia (incipient perithecia) in the other. The authors describe experiments by which they claim to show that mycelia do not pass from one arm to the other and therefore they attribute the formation of perithecia to the stimulation of a hormone. Dodge (1932) and Aronescu (1933, 1934) repeated these experiments and found that one type of mycelium grows into the other arm if air pockets are formed. Aronescu also dissected and grew the ascospores from single asci and in every case found a segregation of the two mating-types in a 1:1 ratio. There is reason to suppose, therefore, that the U-tube method does not afford a satisfactory means of keeping the two types of mycelium apart after air pockets develop in the culture. Lindegren (1934a) has suggested that the line producing perithecia in Moreau and Moruzi's experiments is a self-sterile "bisexual" heterokaryon and that hormones produced by the second line neutralize the effect of the self-sterility factors. More recently Moreau and Moreau (1938a, b) have made further experiments which appear to show the presence of a hormone concerned with perithecium production in *N. sitophila* and *N. tetrasperma*. Cultures of one mating-type were grown on cornmeal agar in a petri dish. When the cultures were well grown the agar was sterilized by heating with steam without pressure for 10 minutes, or by treating with ether or chloroform vapor. Afterwards samples were taken from the agar and incubated, and at the same time the agar was inoculated with the opposite mating-type. The samples showed no growth, indicating that the original mycelium had been killed by the treatment, and the mycelia of the opposite mating-type showed perithecial formation, though somewhat irregularly. This is taken to indicate that perithecial formation is stimulated by a hormone not completely stable at 100° C. Unfortunately Moreau and Moreau do not report on the mating-type reactions of the cultures coming from such perithecia. If the asci result from self-fertilization of a truly "unisexual" type they should produce spores of one mating-type only. If however they are the result of accidental contamination with the opposite mating-type or of the effect of hormone action on a dikaryotic potentially "bisexual" type, they should give cultures of both mating-types. It is conceivable that a potentially "bisexual" type might give one mating-type reaction only but when selfed it should give spores of both types.

In the absence of evidence that the ascospores produced by selfing induced by hormone action are of one mating-type only, we must continue to believe that the sexual reaction involves the fusion of two nuclei of opposite mating-types. On the view that hormone action in itself is sufficient to induce ascus formation in a "unisexual" mycelium, occasional selfed perithecia would be expected to occur in ordinary crosses. Thousands of asci have been dissected by the Lindegrens and others without such perithecia having been found, except in lines which could be shown to be heterokaryotic for mating-type.

Sexual Reproduction as the Result of Hormone Action and the Fusion of Nuclei of Opposite Mating-Type. There is considerable evidence that sexual reproduction in *Neurospora* depends upon the fusion of two nuclei of opposite mating-types, and no conclusive evidence that it can occur without this. Nevertheless, there are certain reasons for supposing that hormones may play a part in sexual reproduction.

Single-spore cultures of different mating-types, if kept isolated, can produce sclerotia or incipient perithecia. The extent to which these are produced depends upon the strain of fungus and the cultural conditions. Both mating-types can produce these sclerotia under suitable conditions. Nevertheless they seem to be produced much more rapidly in the presence of the opposite mating-type, which may indicate that one mating-type secretes a substance stimulating incipient perithecium formation in the other.

The behavior of self-sterile "bisexual" heterokaryons, which when brought into contact with a heterothallic line produce selfed as well as crossed asci, is best explained by assuming that the self-sterility is removed by the stimulus of substances produced by the heterothallic line. The experiments of Moreau and Moreau also appear to indicate the occurrence of a hormone connected with perithecium formation.

It seems feasible that the formation of functional perithecia is dependent upon a hormone which can only be produced by "unisexual" lines or which is dependent for its formation on the interaction of lines of opposite mating type. On this hypothesis the occurrence of selfing in a "bisexual" strain is believed to be due to the somatic segregation into one or more "unisexual" types, leading to perithecial formation. "Bisexual" lines that are self-sterile are believed to be so because of the suppression of somatic segregation in these lines. Self-fertilization may be induced in such types by bringing them into contact with "unisexual" lines of independent origin, with a consequent stimulus to perithecium formation.

If perithecium formation is dependent upon the presence of a "unisexual" line or the interaction of lines of opposite mating-types, it is clear that the production of somatic heterokaryons involving nuclei of opposite mating-types must not take place if sexual reproduction is to occur. This phenomenon by which heterokaryons may be readily formed by mycelia with nuclei of the same mating-type but not between those of opposite mating-type is probably very widespread. Zickler (1934) was the first to prove that in certain heterothallic ascomycetes the sterile part or framework of a perithecium is not formed by an intermingling of hyphal branches from both mating-types grown in the culture. On the contrary, if a perithecial primordium arising, for example, from a reddish-brown mycelium of *Bombardia lunata* is spermatized with spermatia from a greenish mycelium of opposite mating-type, the mature perithecium will be reddish-brown; and vice versa. Hansen and Snyder (1943) describe two lines in *Hypomyces solani* f. *cucurbitae*, one with red, the other with white perithecia. In crosses between these two lines the perithecia are either red or white, indicating that only one mating-type goes to form the framework of a single perithecium. Vandendries (1934) described an apparently similar type of behavior in the basidiomycete *Lenzites betulina* (L.) Fr. In this species, there are four mating-types depending upon two factor-pairs, and there is a "barrage sexuel" between *b* and *b′* and independent of *a* and *a′*.

The capacity to form heterokaryons may not be determined by the mating-type factors alone. Indeed one case was observed in which two mutants of the same mating-type would not form a heterokaryon when grown together. It is possible that the reverse phenomenon, by which modifying factors permit the vegetative association of lines of opposite mating-type, may also occur. Such modifying factors would account for the behavior of the self-sterile "bisexual" heterokaryons described by Lindegren. Somatic segregation in such a type would be followed by re-fusion so that perithecium formation would not occur. The effect of somatic segregation would also be neutralized if the segregants had a lower growth-rate than the heterokaryon. However, this explanation would not account for the "sterile" combinations between lines derived from the "bisexual" strains, whereas vegetative fusion would.

In the heterothallic species, therefore, sexual reproduction seems to involve at least two types of reaction. The production of functional perithecia seems to be dependent upon the presence of "unisexual" lines, possibly of two types, and the actual process of fertilization depends upon the fusion of two nuclei of opposite mating-type in the young ascus. Sexual reproduction therefore depends upon an interaction between *mycelia* of opposite mating-type, in which hormone action may be concerned, as well as upon the fusion of nuclei of opposite mating-type. In the "homothallic" forms, the interaction between mycelia of opposite mating-types has been eliminated. The "bisexual" mycelium forms perithecia without any external stimulus. The way in which the secondary homothallic type has evolved from the heterothallic one is a problem that requires further investigation.

Beadle and Coonradt (1944) suggest that the phenomenon of heterokaryosis is a step in the evolution of a sexual reproduction. This assumes that the *A a* factors are true sex factors. However, it seems more probable that *Neurospora* is hermaphrodite and the *A a* factors are more closely related to incompatibility factors (Sansome & Philp 1932) since both types produce ascogonia, the female sex organs, and microconidia which may correspond to spermatia. A consideration of the work of Zickler (1934, 1937) on ***Bombardia lunata*** and that of Hansen and Snyder (1943) on ***Hypomyces solani* f. *cucurbitae*** is in confirmation of this view. In ***Bombardia*** what appear to be true sex factors are inherited independently of the mating-type factors. The primitive sexual condition was probably an 8-spored homothallic type, heterothallism being a derived condition. The present work indicates that heterokaryosis could not have been a step in the evolution of the heterothallic system, since a suppression of heterokaryosis is associated with the mating-type factors. Heterokaryosis is probably a fairly primitive condition since it is of widespread occurrence. On the other hand, it may have evolved independently in different groups, especially since it is a very favorable condition. It would appear to be the ideal condition for a multinucleate, relatively undifferentiated organism because of its extreme flexibility, giving the possibility of rapid adaptation to different conditions. The heterothallic species such as *Neurospora crassa* are able to form heterokaryons within each mating-type and under suitable conditions sexual reproduction takes place between opposite mating-types. In the secondary "homothallic" types such as *N. tetrasperma* the *A a* nuclei are associated throughout the life history and there is no restriction on heterokaryosis.

SUMMARY

The following evidence indicates that heterokaryons are not normally formed involving the *A* and *a* factors in *N. crassa*. The *A* and *a* nuclei appear to be kept apart until the time of sexual reproduction and are probably brought into association by way of the trichogyne.

X–8 A and *X–9 A* cultures readily form heterokaryons with greatly increased vigor. *X–8 a* and *X–9 A* combinations remain mutant in appearance. Hyphal tip isolations from perithecia of this combination gave 18 cultures of *X–8* type and 30 of *X–9* type. In a second cross, from which eight perithecia were isolated, 101 hyphal tip cultures all of *X–9* type were obtained.

In a similar experiment involving two further mutants, *X–10* and *X–11*, it was found that the colonies formed by individual perithecia could be classified as *X–10* or *X–11* in type. Fifty-four perithecia of *X–10* type and 28 perithecia of *X–11* type were isolated. Hyphal tip isolations from the *X–10* type perithecia were *X–10* type in appearance, and small inoculum transfers from the *X–11* type of perithecium were *X–11* type in appearance. All such isolations were "unisexual" and when tested the *X–10* type were *A* and the *X–11* type were *a* in mating-type reaction.

These results are discussed in relation to the behavior of the "homothallic" species *N. tetrasperma* and to theories on the role of hormones and nuclear fusion in sexual reproduction in *Neurospora*.

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SELF-STERILITY IN "BISEXUAL" HETEROCARYONS OF NEUROSPORA

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In the work on heterocaryotic vigor in *Neurospora tetrasperma* (Dodge, Schmitt & Appel, 1945) we found at times that certain factors must be interfering with the orderly development of perithecia in cultures of some of the f_1 heterocaryotic segregant races. If we consider merely the obvious effects, there appeared to be at least two or three kinds of sterility. (1) Many perithecia developed to full size in the culture, but no asci ever arose in them. The full functioning of the mating-type factors had been blocked, but not until the framework of the perithecium had been completed. The sterility factors became effective first at the critical stage of sexual reproduction, namely, at the formation of ascogenous hyphae. It might have been a simple matter to eliminate these interfering factors, but our problem was to follow the complementing factors for heterocaryotic vigor as they were handed down by the parent races along with the sterility factors regardless of how much trouble the latter gave us when it came to genetic considerations. (2) Some of our bisexual f_1 heterocaryotic races grew vigorously in culture, but only a very few perithecia made their appearance. Races in this group were of two kinds. The few perithecia that were finally developed in certain cultures delimited many ascospores, while no asci were formed in perithecia of other races. (3) No perithecia were ever formed in cultures of certain races which were later proved to be heterocaryotic for mating type factors. It was believed that the operation of the "sterility" factors in groups (2) and (3) above was merely one of degree of the sterility affected, rather than a difference in the nature of the factors which limited the number of perithecia in a culture.

Experiments with breeding races of *N. sitophila* which will be described later seem to afford one possible explanation for the sterilities in groups (2) and (3) of *N. tetrasperma* noted above. The same explanation may apply to the "bisexual" self-sterile heterocaryotic races of *N. crassa* discussed by Lindegren (1934) and by Sansome (1946), and to certain cross-sterilities between two unisexual races even though they are of opposite mating types.

Aronescu (1933), working in this laboratory with certain non-conidial races of *N. sitophila*, made crosses between two races, one of which developed large numbers of incipient perithecia, and the other of which produced very few if any of these receptive structures. She isolated the eight spores from some of the F_1 asci and proved for the first time that the factors controlling the relative abundance or paucity of incipient perithecia produced by individual races are segregated at meiosis. She could not carry on this work to its theoretical conclusion. That is, she did not mate or grow together in culture two races of opposite mating-type, each of which produced by itself an abundance of incipient perithecia, and then by contrast grow together two races of opposite mating-type, neither of which developed by itself any of these receptive bodies. This the writer has now done. The results of such matings, as well as brief studies made on a few "wild type" conidial races from bread from various localities, will be reported here.

The races employed by Aronescu were obtained by mating two non-conidial races of *N. sitophila* originally described by the writer (1930). She did not give the full pedigree of the strains she used but it is certain that they were both direct descendants from the mating 56.2 × 56.6. Both these races originally produced an abundance of incipient perithecia. Backus (1939) employed them in his excellent work on "conidiation." The writer has carried these races in culture for 17 years. Race 56.2, mating-type *a*, has not changed materially, but race 56.6, mating-type *A*, no longer produces incipient perithecia. We shall from now on refer to these receptive bodies as "protoperithecia," a good term coined by Buller. The symbol *P* will be used to designate a race that produces by itself protoperithecia, and *p* will be used to designate a race that produces few if any of them.

Ascospores from the mating 56.6 × 56.2 were sowed on plates of Difco potato-dextrose agar and then given the heat treatment. Some 200 or more single germinating ascospores were isolated and grown in tubes. These cultures were observed frequently for several weeks to determine which ones produced protoperithecia and which ones did not. In the meantime the mating-type, *A* or *a*, of each of 152 of these f_1 segregant races was determined. The tester races used were 56.2, mating-type *a*, and f_1 races Nos. 36, 39, 44, and 50, which were mating-type *A*. All five testers produced many protoperithecia. The results of these tests were as follows: 73 were mating-type *A* and 79 were mating-type *a*; 72 were *P*, producing protoperithecia, and 80 were *p*, producing few if any protoperithecia; or 34 *PA*; 38 *Pa*; 39 *pA*; 41 *pa*, that is, 77 old combinations to 75 new combinations. There was no evidence of linkage.

From the 80 races which did not seem to produce protoperithecia we chose thirty-four races at random. Fourteen of these happened to be mating-type *A* and twenty were type *a*. These were divided into two groups each of which included seven of mating-type *A* and ten of type *a*. Within each group the races were grown together in pairs in all combinations of the *A* and *a* types, and checks with the parent races 56.2 and 56.6 were also included. The cultures of the mated races were observed for several weeks or until they dried out. Not one of the 140 mixed cultures produced perithecia. No *pA* race fruited with a *pa* race, and no *pa* race fruited with the tester 56.6, which is *pA;* but all the *pA* races so far as tested fruited with the tester 56.2, which is *Pa.* Zickler (1934), working with *Bombardia lunata*, indicates by his diagrams that he was unable to obtain perithecia when he cross-spermatized two races neither of which produced protoperithecia. He does not state, however, that he also grew his two races together in the same culture.

So far as our experiment goes we must believe that either the one or the other of the two races mated must produce protoperithecia if fertilization leading to production of perithecia is to be consummated. We found no evidence that a race *pA* could stimulate the formation of protoperithecia by a race *pa*, or vice versa. This does not mean, however, that a race which is producing a *few* protoperithecia in a culture may not be induced to produce additional protoperithecia, as Sansome (1946) also appears to believe, by a change in the medium, by the addition of hormones, by the introduction of some other race into the same culture, or by the application of microconidia or monilioid conidia. It is clear that whenever a race which has been proved to be heterocaryotic for mating-type factors *A* and *a* fails to produce perithecia, it may well be that neither component of the heterocaryon could produce protoperithecia if grown by itself.

Heretofore whenever we have grown races 56.2, *Pa*, and 56.6, *pA*, together in culture, protoperithecia always developed. It would be curious reasoning to call this a dominance of *P* to *p*, or to say that protoperithecium-formation is a dominant character, especially as we have not yet proved that a mingling of these two mycelia in culture ever results in heterocaryosis. This work should be carried on further in the light of Sansome's report (1946) that in the obligately heterothallic species, *N. crassa*, one can readily obtain heterocaryotic races by growing two different races together provided these races are of the *same* mating-type, but not when they are of *opposite* mating-type. The writer, working with the same "Abbott" race of *N. crassa* has fully confirmed the latter part of her claim. The first part would also be confirmed if we grew our race 56.6, which is *pA*, with race f_1 200, for example, which is *PA;* or grew race f_1 210, *Pa*, with race f_1 280, *pa*. In both cases protoperithecia will be formed in the cultures but one will not know whether or not the mycelium is really heterocaryotic until both components, either *PA* and *pA* or *Pa* and *pa*, can be isolacted from a mycelium derived from a single-tip isolate from the suspected heterocaryon. Would it not be illuminating to find that the heterocaryons, either (*Pa* – *pa*) or (*PA* – *pA*), would not produce protoperithecia in culture? It would be difficult to refute the argument that *p* is dominant to *P* and therefore we should transpose our symbols. The writer was much disturbed by the results of certain plate culture experiments which showed a sort of composite effect of a type of "dominance" such as just hypothesized above.

"DOMINANCE" IN MULTI-SPORE CULTURES

The plate cultures from which the 200 or more germinating ascospores had been isolated, as noted earlier, were set aside for several weeks. Many germinating ascospores still remained in each plate and these spores had continued to grow. There were, therefore, probably two or three hundred different f_1 mycelia in each plate. Approximately 50 per cent of these mycelia must have carried the factor *P* for protoperithecia and the rest must have carried *p*. The mating-type factors, *A* and *a*, must also have been equally represented. Theoretically, protoperithecia and later perithecia should have developed in these plates. Such was not the case, however; none of these bodies was found in the cultures even after several weeks. Believing that some faulty technique or culture conditions were responsible for this apparent "dominance" of the factor *p*, we repeated the experiment three times sowing as before many ascospores on plates of potato-dextrose agar. After heat treatment it was seen that many ascospores had germinated, but none of them was removed from the plates. The results were the same as before. No protoperithecia and no ascocarps ever developed in any of the eight different plates, although in each there must have been a hundred or more mycelia of each mating-type and fifty per cent of them would, if isolated and grown by themselves, have produced protoperithecia. Since no receptive bodies were ever developed in the plates no perithecia could be expected to form. The failure of such multispore cultures to produce protoperithecia was probably merely a reaction to unfavorable culture conditions brought about by the excessive dosage of germinated ascospores. It has nothing to do with dominance. A similar experiment but made with a different culture medium might have resulted quite differently.

The writer is indebted to Mr. Charles Beall for isolating over 200 germinating f_1 ascospores from the mating 56.2 × 56.6. He recorded that of the 162 f_1 races studied 107 were judged to produce few if any protoperithecia. Observations made after his cultures had dried out, however, proved that quite a few of these cultures had actually good protoperithecia which had been overlooked. Only 53.2 per cent of those checked failed to produce receptive bodies. In both sets of our experiments the numbers of races that failed to produce protoperithecia were somewhat in excess of those that developed these bodies.

Aronescu (1933) inoculated the medium in one arm of a U-tube with two races of *N. sitophila*, one of which was conidial and the other non-conidial, the two races being in each case of opposite mating-types. Perithecia soon developed in the first arm at the point of inoculation. In due time mycelial hyphae appeared at the surface of the medium in the second arm. In both U-tubes figured in her plate 14, the mycelia that finally appeared in the second arm bore conidia. Was this a proof of heterocaryosis attained, and of the dominance of C to c? The answer is no. She proved that only *one* of the two mycelia used in the 86 experiments ever arrived in the second arm. The one that got started first or had the faster inherent growth rate was the one that "dominated" the situation. Aronescu did not in any case inoculate the one arm with non-conidial and conidial races both being of the *same* mating types. She did prove, however, that heterocaryosis was not consummated in any case where the two races were of *opposite* mating-types.

Certain other experiments involving tests for mating-types indicate how badly one can be misled by superficial appearances when judging heterocaryotic conditions and so-called dominance in mixed cultures. A few examples will illustrate this point. Voth 2, Voth 5, Wall, Sands, HSS f_1, 1, 5, 8, 15, and 24 were all conidial, mating-type A. Voth 4, HSS f_1, 17, 22, 28, and 33 were all conidial, mating-type a. Each of these races was grown separately in mixed culture with race 56.2, non-conidial, mating-type a. The mixed cultures Voth 4 + 56.2 $(a+a)$ and Wall + 56.2 $(A+a)$ produced many characteristic orange-colored conidia, while all the other mixtures with 56.2 were albinistic and practically non-conidial. All mixtures of opposite mating-types produced perithecia, proving that both races in each case grew well. The races in mixtures 56.2 + HSS f_1, 33 and 56.2 + HSS f_1, 17 were of the same mating-type and so both mixtures could have been heterocaryotic. Some would claim that c was dominant to C. In mixture 56.2 + Voth 4 $(A+a)$ however the C was "dominant" to c.

PROTOPERITHECIA ON WILD-TYPE MYCELIA

Shear and Dodge (1927) noted that certain races of *Neurospora* produced numbers of little "sclerotia" or "bulbils," as they called them, while other races produced very few of them. The following year the writer (1928) said: "Mycelia of species of *Neurospora* produce coiled structures which very likely are morphologically equivalent to sex organs." It was not until later (1932, Dodge & Swift 1933) that it was proved experimentally that the "sclerotia" of *Neurospora* are receptive structures. Since then we have been careful to keep as our tester races only those that develop incipient perithecia when grown alone. Whether or not races being tested produced them was usually not recorded.

The failure of race Dwarf 16 (Dodge, Schmitt & Appel 1945) to produce protoperithecia could be due to the blocking effects of the dwarf factor v. This same dwarf race does not produce the monilioid conidia in culture, but it has been proved genetically that it carries the factor C for conidia. This factor *C* is also blocked, or prevented from expressing its effects, by the dwarf factor *v*.

During the past year we have received several samples of moldy bread from various sources and so have been able to make a few more observations on the production of protoperithecia by wild-type races of *N. sitophila*. The "Beall" race, mating-type *A*, for example, produces very many large protoperithecia. The "Sands" race, also mating-type *A*, produces many definite protoperithecia, but they are small. A sample of moldy bread "HSS" was brought in by students of the Bronx High School of Science. Cultures from the bread produced some perithecia and so must have originally contained both mating-types. Many single tip cultures were all unisexual, mating-type *a*. Fifty single ascospore cultures were also studied. Thirty-five of these races were tested for mating-type. Eighteen were *A* and 17 were *a*. None of these races produced *easily recognizable* protoperithecia in any abundance on a malt extract agar medium. However, one could usually find scattered here and there quite a few small *colorless* bodies which could probably function as protoperithecia. It is such races as these that should be studied more extensively. We know from earlier studies that some races produce protoperithecia that continue to grow to reach the size of mature perithecia without fertilization. This HHS material represents races which do not develop characteristic protoperithecia, that is, receptive bodies easily seen with a hand lens, and which turn brown after a few days.

Professor P. D. Voth sent us several different cultures of *N. sitophila* taken from bread in Chicago. None of these produced what might be called "typical" protoperithecia. Voth 4, mating-type *a*, grown in plate cultures on cornmeal agar seemed to be entirely devoid of protoperithecia for a whole week, yet when conidiated with the Sands race this plate developed quite a few good perithecia and also numbers of good protoperithecia which were confined to the spot conidiated.

The writer, after some study of the wild-type races mentioned above, is not in a position to warrant any conclusions whatever on this matter of production of protoperithecia. Receptive bodies may often consist merely of differentiated special hyphal branches which would be called ascogonia. If they were not conidiated or spermatized they might not go on to grow into what we call protoperithecia. Whether or not production of ascogonia or protoperithecia is regulated by a single pair of factors is still a question. The results of the experiments with the non-conidial races 56.2 and 56.6 seemed to show rather definitely that factors *P* and *p* had been segregated according to Mendelian principles at reduction. No such clear cut segregation was evident when we studied such wild type races as the HHS and Voth races. Nevertheless, it is clear that in all studies of sterilities or incompatibilities which are concerned with the production of perithecia it is important to determine whether (and to what extent) the races being analyzed are capable of producing receptive bodies, be they simple ascogonia or the more complicated protoperithecia.

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BULLETIN OF THE TORREY BOTANICAL CLUB
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SPORANGIAL PROPAGATION OF BLUE MOLD FUNGUS ON ASEPTICALLY GROWN TOBACCO SEEDLINGS

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Peronospora tabacina Adam, which is the cause of the blue mold disease of tobacco, can be propagated only on its host. Its freedom from extraneous microorganisms cannot, therefore, be brought about by standard culture methods. The desirability of pure culture is apparent for nutrition studies with the fungus, and perhaps for checking symptoms obtained with this disease in nature.

It has been found possible to grow the fungus on one-month-old tobacco seedlings propagated aseptically in 200-cc. Erlenmyer flasks on 50 cc. of a mineral agar. The seedlings were grown at room temperature under 500 foot candles of intermittent or continuous light provided by 3500° white fluorescent lamps. Details of the procedure will appear elsewhere.[1] Seedlings of Maryland medium broadleaf and Xanthi Turkish proved satisfactory. Inoculation of seedlings was on the lower leaf surfaces. A straight sharpened needle was used to pick up a bit of filter paper pulp from sterile suspension, rubbed over a leaf covered with spores and placed on a healthy leaf. Almost invariably infection took place if the leaf tissue was injured and the mixture of spores and pulp applied at this point.

The flasks were then kept in the bottom of a lighted refrigerator[2] in a glass moist chamber at 45–50° F for 7 days. They were then removed from the moist chamber and placed in the top of the same refrigerator where the temperature was about 72° F. Spores began to appear on the upper surfaces of the inoculated leaves on the seventh day and increased in profusion up to the twelfth day. Viable spores were still present after infected plants were held in the lighted refrigerator for a total of 3 weeks and stored in the dark at 41° F for 2 additional weeks. Excellent propagation of the fungus was also possible at a uniform temperature of 59° F, obtained by a 25-watt tungsten lamp in a refrigerator of 5 cubic feet capacity.

The fungus was maintained in this manner for over a year, a total of 27 successive transfers. All contaminating microorganisms had disappeared by the third transfer. The symptoms of infection were similar to those in nature, except for greater profusion of spores on upper instead of lower leaf surfaces. Other leaves of the plant than those inoculated often became infected. Blackening at the base of leaf midribs and of stems indicated the path of the fungus was, in some cases, through these tissues. Roots of infected plants remained apparently healthy.

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[1] **Steinberg, Robert A.** Growth responses to organic compounds by tobacco seedlings in aseptic culture. Jour. Agr. Res.

[2] **Wolf, Frederick A. & McLean, Ruth A.** Sporangial proliferation in *Peronospora tabacina*. Phytopathology 30: 264–268. 1940.

Good sporulation was obtained on leaves detached immediately before inoculation, the bases of which had been plunged into the agar. Turgid seedlings growing on agar that had almost dried completely also permitted profuse sporulation of the fungus.

Light appeared necessary for sporulation, since no spores were formed if the flasks were wrapped in black paper during the latter 2 weeks of the 3-week period. Absence of light during the fungal vegetative period (first week after infection) retarded sporulation partially or completely, depending probably on the completeness with which light was excluded. Those seedlings in which sporulation was thus suppressed remained healthy subsequently. Growth of the seedlings after infection in a stream of CO_2-free air appeared to be without influence on development of the fungus. Growth of the fungus, therefore, would seem independent of the immediate products of photosynthesis. The fungus could not, however, be propagated sporangially on seedlings killed by vapors of carbon tetrachloride, ammonia, or alcohol.

Attempts to cultivate *P. tabacina* on media proved uniformly unsuccessful with many standard and experimental formulae. Materials aiding germination of spores always proved ineffective for growth in media. Germ tubes 10 or more times the spore diameter were often formed before growth stopped. The absence of all growth in these tests also served as a demonstration of the absence of contaminating microorganisms. Included in the different media tested were sap of the tobacco plant and various enzymes—all of which had been rendered aseptic through filtration.

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BULLETIN OF THE TORREY BOTANICAL CLUB
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STRUCTURE AND REPRODUCTION OF TRICHOGLOEA REQUIENII, WITH A COMPARISON OF THE GENERA OF HELMINTHOCLADIACEAE*

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In spite of the fact that the Nemalionales are better known than any other order of the red algae as regards the developmental morphology of the genera, there are still, as in all large groups of organisms, a number of gaps to be filled before the outline of the picture is complete. Among the genera requiring study is the tropical genus *Trichogloea.* It belongs to the family Helminthocladiaceae, which includes among others the classical *Nemalion* as well as such familiar names as *Helminthocladia, Helminthora,* and *Liagora.* The material for the present study was collected in Hawaii during the years 1941 and 1942.

Butters (1903) has given a good account of the structure of the thallus and has described and illustrated certain stages in the development of the reproductive organs of one species. Nonetheless, the steps that lead up to the formation of the mature gonimoblast are not well enough understood to allow a detailed comparison with related genera.

As in *Liagora*, the thallus is lime-incrusted and the genus may at times be mistaken for the latter. This resemblance is purely superficial, however, for by the position and form of the carpogonial branch and by the development of the gonimoblast and associated structures, *Trichogloea* shows itself to be more closely related to *Nemalion* than to any of the other genera of the Helminthocladiaceae which have been investigated. Before taking up the structure and reproduction, it may be well to give a brief summary of the history and geographical distribution of the genus and to discuss the reasons for identifying the plants studied with *T. Requienii* (Mont.) Kütz.

The genus *Trichogloea* was established by Kützing in 1847 upon a plant from the Red Sea which Montagne (1843) had described a few years earlier as *Batrachospermum Requienii.* Since that time, two additional species have become known: *T. lubrica* J. Agardh (1876) and *T. subnuda* Howe (1934). For a complete record of the early literature on the genus, reference should be made to the "Sylloge Algarum" of De Toni (1897).

After the description by Montagne, *T. Requienii* was reported from the Red Sea for a second time by Zanardini (1858), who also gave the first good illustration of the habit of this alga. Later, the species was recorded from

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* The publication of the illustrations has been assisted by the Lucien M. Underwood Memorial Fund.

Madagascar (Pilger 1908), Mauritius (Børgesen 1942), Ceylon and the Malayan Archipelago (Weber-van Bosse 1921); and to judge from the descriptions and illustrations of Okamura (1923, 1930, 1936), it seems very likely that the plants from Japan which he has referred to *T. lubrica* are also representative of *T. Requienii.* The species is here reported for the first time from Hawaii.

Trichogloea lubrica was described by J. Agardh in 1876 from a specimen of the plant which Harvey had distributed as no. 46 of his "Friendly Islands Algae" under the manuscript name *Liagora lubrica.* Subsequently the species was reported from various places other than the Tonga Islands. None of these records, however, seems to be based upon true *T. lubrica.* The reports from Mauritius by Jadin (1934) and others have been shown by Børgesen (1942) to apply to *T. Requienii,* those from Hawaii by Tilden (1901b) and Butters (1903) have been found by Howe (1934) to be based upon *T. subnuda,* and in the paragraph above the opinion is expressed that the reports from Japan apply to *T. Requienii.* The only other records of *T. lubrica* are those from Guadeloupe (cf. De Toni 1897) and Barbados (Vickers 1905) in the West Indies. These reports are probably based upon an undescribed species, which may be identical with the plant from Bermuda (Collins and Hervey 1917; Howe 1918) which passes under the manuscript name of *T. Herveyi* Setchell.

The third species of *Trichogloea, T. subnuda,* was described by Howe (1934) from material from Hawaii. In the same paper, he also pointed out that the Hawaiian specimens which Tilden (1901a) had distributed as *Nemalion ramulosum* Harv. under no. 419 of her "American Algae, Century V" actually were *T. subnuda.* This material was also published by Tilden (1901b) under the name *T. lubrica* and part of it formed the subject of a paper by Butters (1903) entitled "Observations on *Trichogloea lubrica.*" Thus far *T. subnuda* is known from only two localities on the island of Oahu: Kahuku Point, where it was obtained among the driftweed by Miss Tilden in June, 1900; and Kaneone Bay, where it was secured by Galtsoff in July, 1930. Both these stations are situated on the northeastern side of the island. Most of the writer's specimens of *T. Requienii* were collected along the southern shores of Oahu.

As will be seen from the photographic reproductions which Howe (1934) has given either of the type or of authentic specimens of the three validly published species of *Trichogloea, T. lubrica* is a much more robust plant than either *T. Requienii* or *T. subnuda.* The plump habit of *T. lubrica* is also shown by a duplicate of the original material of Harvey (Friendly Islands Algae, no. 46) which is in Herb. Univ. Calif. (no. 696847) as well as by a photograph in this Herbarium of the Tonga Islands specimen of Harvey which is in Herb. Sydney Bot. Garden.

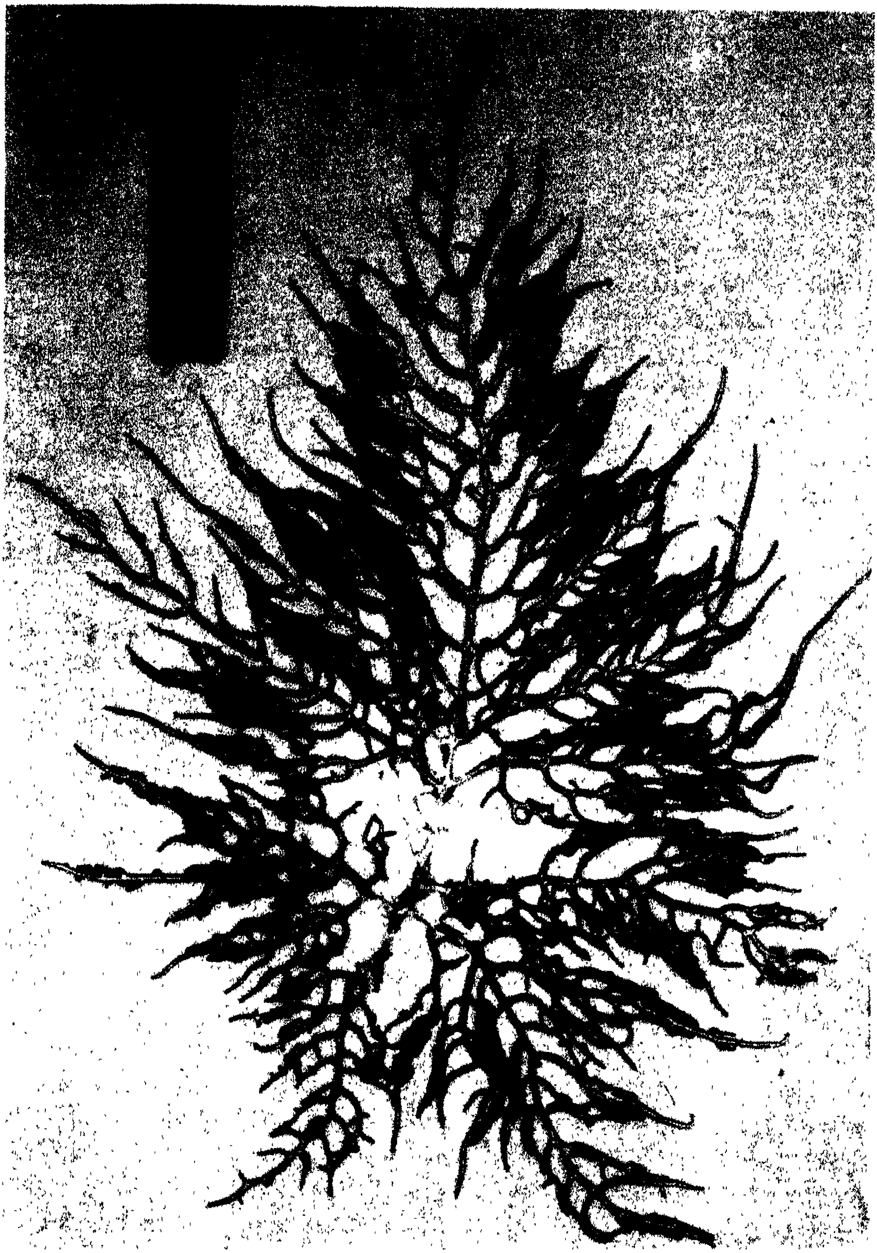

FIG. 1. *Trichogloea Requienii*. Habit of plant from Waikiki, Oahu, Hawaiian Islands (Herb. Univ. Calif. no. 696848). Leg. G. F. Papenfuss, March 21, 1941.

In habit, the Hawaiian specimens studied by the writer (fig. 1) differ very much from *T. lubrica.* The plants are identified with *T. Requienii* rather than *T. subnuda,* which, as has been said, was described from Hawaii by Howe, because the cells of the carpogonial branch give rise to comparatively well developed sterile or so-called involucral filaments.

In *T. subnuda,* these filaments, according to Howe, are of a rudimentary nature. In fact, this is the structural feature upon which the specific name is based and the one whereby *T. subnuda* is most readily distinguished from both *T. Requienii* and *T. lubrica.* Howe established this from a comparison of *T. subnuda* with authentic material of *T. Requienii* and *T. lubrica.* In the two latter species, he found the sterile filaments to show more or less the same degree of development.

The observations of Howe on the nature of the sterile filaments of *T. subnuda* and *T. Requienii* have been verified by the writer from examination of an example of *T. subnuda* which Miss Tilden distributed as no. 419 of her "American Algae," and of a fragment of the female type of *T. Requienii,* which was obtained from Museum Hist. Nat. Paris by the late Professor Setchell.

In their irregular manner of branching the writer's Hawaiian plants also show greater agreement with *T. Requienii* than with *T. subnuda.* In the latter, the branches are more or less dichotomous in arrangement (cf. Howe 1934, fig. 1).

In Hawaii, *T. Requienii* is a spring and summer annual. The earliest record of the season was obtained from specimens which were collected at Waikiki on February 24, 1941, and the latest record was furnished by plants which were secured on August 23, 1941, on the shore below Diamond Head. The plants obtained on February 24 were up to 7 cm. high and already fertile; and those collected on August 23 still contained reproductive organs.

The material used in this study was fixed in a slightly modified solution of Karpechenko.[1] This fixative the writer has found very useful for marine algae. In addition to being a good fixing agent, Karpechenko's solution has the merit of leaving no apparent deleterious effects even when material of most algae is allowed to remain in it for several days. The advantages of this to one who wishes to fix material while on a few days' collecting trip, with little or no time, nor facilities for washing and dehydrating, are obvious. Owing to its comparatively high acid content, Karpechenko's fluid also has the utility of completely decalcifying such lime-incrusted algae as *Liagora, Galaxaura,* and *Trichogloea.*

Selected parts of the plants were stained in 1 per cent anilin blue according to the usual procedure with this dye. The small pieces were next treated with 1 per cent hydrochloric acid for about fifteen minutes, washed, run up to about 70 per cent glycerine, mounted in pure glycerine, and crushed by applying pressure to the cover-glass. With a little practice the suitable degree of dissociation of the tissues is easily obtained. The facility with which the tissues will separate depends largely upon the consistency of the thallus and the length of treatment with hydrochloric acid.

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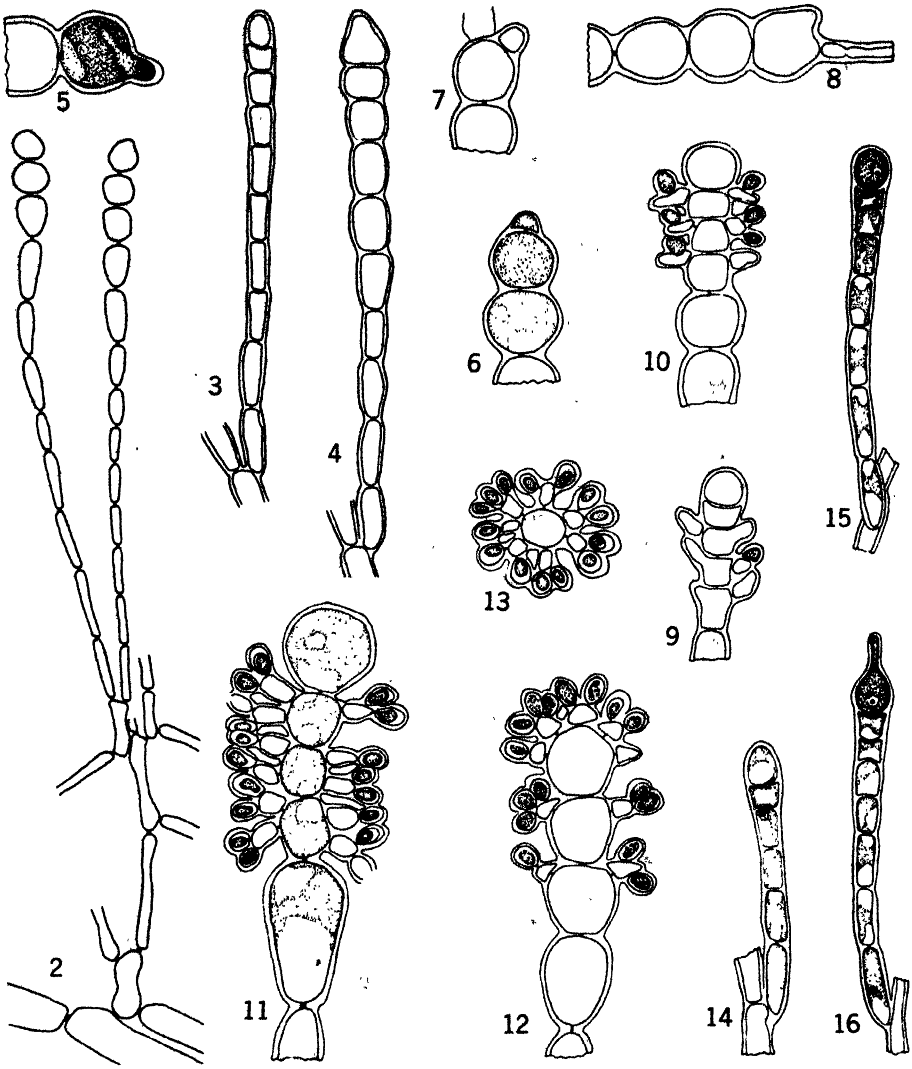
[1] This solution was made up as follows: Part A—chromic acid 1 gm., glacial acetic acid 5 cc., sea water 65 cc. Part B—commercial formalin 40 cc., sea water 35 cc. Parts A and B are kept separately and equal amounts are mixed as required.

Structure of the Thallus. The habit of *Trichogloea Requienii* is indicated in figure 1. Structurally the thallus agrees with that of *T. subnuda,* the anatomy of which has been described and illustrated by Butters (1903) under the name *T. lubrica.* A brief account will consequently suffice here.

As in *Nemalion* and other Helminthocladiaceae, the thallus is composed of a central tissue of intertwined, branched, colorless filaments, from which issue numerous radiating, branched, assimilative filaments (fig. 2). The basal cells of the assimilatory branches send out from their proximal ends descending, but at times also ascending, filaments which contribute to the multiaxial core (fig. 2). In addition, the primary and later orders of assimilatory filaments also give rise to higher orders of similar filaments. All radially directed filaments usually remain simple, however, for a distance of eight or more cells inward from the periphery of the thallus (fig. 2). When mature, these unbranched portions of the assimilative filaments are composed of cells which are moniliform near the surface but become progressively longer and narrower toward the center of the thallus (fig. 2). In young assimilatory filaments (figs. 3, 4), the bead-like form of the cells is less striking. Mature assimilative cells contain a large, parietal, lobed chromatophore and a centrally located pyrenoid.

Hairs are of common occurrence in *T. Requienii.* They are initiated as papilloid outgrowths and usually issue from the terminal cell, but at times also from the penultimate cell, of the assimilative filaments (fig. 5). The primordium is separated from the mother-cell at an early stage by a transverse wall (figs. 6, 7), and then grows out into a long, unicellular hair (fig. 17, to the left). Full-grown hairs may attain a length of 0.9 mm. and possibly more, and are of a hyaline appearance, except at the extreme tip, where the cytoplasm is dense. At any one time, a cell bears but one hair. The hairs are ephemeral and may be more or less completely lacking in old plants or older parts. In vigorously growing parts, a cast-off hair is usually, or at least frequently, replaced by a new one (fig. 7). Several crops of hairs may thus be produced by a cell. Not infrequently a new hair may be in the course of formation while the old one is still intact (fig. 17, to the left). Often the new hair is initiated at the place of attachment of the preceding one and can be seen projecting into its empty base. An old hair is shed as



FIGS. 2–16. *Trichogloea Requienii.* FIG. 2. Part of dissociated thallus showing a few of the longitudinal axial filaments (at the lower end) and two of the radiating, assimilative filaments. × 300. FIGS. 3, 4. Young assimilative filaments. × 600. FIGS. 5–7. Early stages in the formation of hairs from the terminal cells of assimilative filaments, figure 7 also showing the empty base of a shed hair. × 600. FIG. 8. Distal end of an assimilative filament and the basal part of an old hair, which shows an early stage in the formation of the constriction which brings about the abscission of hairs. × 600. FIGS. 9–13. Stages in the development of antheridia, figures 9–12 being optical median longitudinal sections of the terminal ends of assimilative filaments and figure 13 an optical transverse section of an assimilative cell. × 775. Figure 9 shows cells which are in an early stage of cutting off antheridial mother cells, one of which has formed an antheridium. Figures 10–13 represent older stages, mature antheridia being shown in figures 11–13. FIGS. 14–16. Early stages in the development of carpogonial branch. × 600. In figure 14 the young carpogonium still contains a chromatophore, figure 15 shows a stage at which the chromatophore has broken down, and in figure 16 the trichogyne is just being formed.

the result of a constriction which develops immediately above its place of insertion (fig. 8). For a summary of knowledge concerning the hairs of Florideae and their probable function in the absorption of nitrates reference should be made to the accounts of Rosenvinge (1911) and Kylin (1937, pp. 37–38).

Development of Antheridia. Although *Trichogloea Requienii* is ordinarily dioecious, occasional plants are monoecious. *T. subnuda* on the other hand, is monoecious according to both Butters (1903) and Howe (1934).

The antheridia are formed on the distal cells of the assimilatory filaments (figs. 9–12). From one to five successive cells may be concerned in their production. Usually the terminal cell remains sterile (figs. 10, 11) but in rare instances it also becomes fertile (fig. 12). Not infrequently the subterminal cell, as well as the terminal cell, or at times even the one below it, remains sterile. In *T. subnuda,* on the other hand, to judge from the account and figures of Butters, the terminal cell of a fertile filament usually forms antheridia.

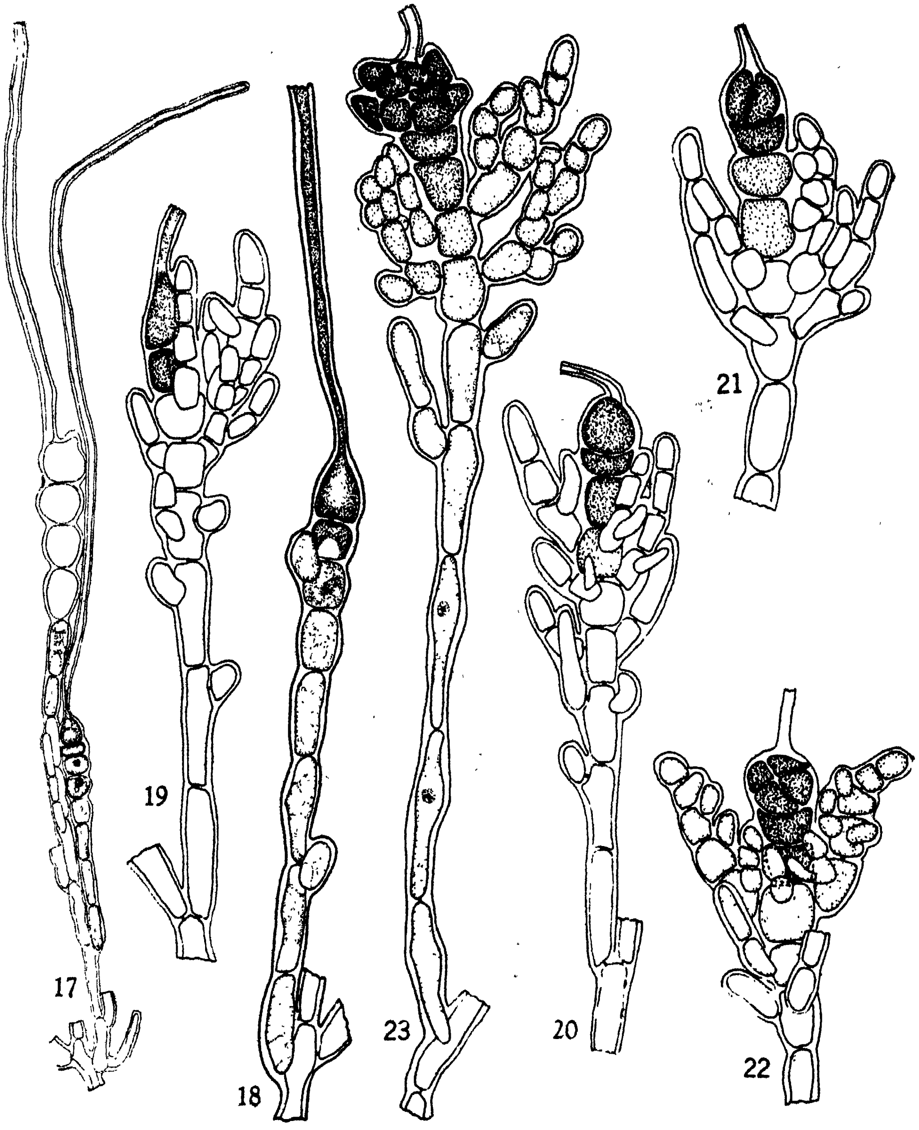
The first step in the production of antheridia is the formation of antheridial mother-cells. These arise as proliferations which become separated from the vegetative cells (fig. 9). The mother-cells are first formed at the distal end of a cell (fig. 9) but soon afterwards also from its basal end. The antheridia are initiated as outgrowths that are cut off from the terminal ends of the mother-cells (fig. 10–13). Each antheridial mother-cell may at any one time contain from two to four antheridia, three being the usual number.

The mature spermatium is set free in the usual floridean fashion by escaping through a split which is formed at the tip of the antheridium. As the spermatia are liberated, new antheridia are formed by the mother-cells and frequently they are situated within the empty cases of former antheridia.

Development of Carpogonial Branch and Gonimoblast. Carpogonial branches are formed in abundance in the younger, terminal parts of the thallus. In smaller numbers, they occur also in older parts.

In *Trichogloea* the carpogonial branch is a modified assimilative filament. This is the case in *Nemalion* also (cf. Kylin 1930, p. 8; 1937, p. 197) but is in contrast to that in the other genera of Helminthocladiaceae. In these the carpogonial branch is formed as an accessory branch by a cell of the radial filaments of the thallus, and is a specialized organ from the time of its inception.

According to Cleland (1919), the carpogonial branch of *Nemalion* can be recognized even in the one-celled stage. This, however, is not the case in *Trichogloea*. Here the future carpogonial branch is morphologically indis-



FIGS. 17–23. *Trichogloea Requienii.* FIG. 17. Almost mature carpogonial branch (to the right) and its supporting assimilative filament, whose terminal cell bears a mature hair and is in course of initiating a new hair. × 315. FIG. 18. Mature carpogonial branch with the cytoplasm of the hypogynous cell somewhat denser than that of the cells proximal to it and two of the cells bearing young sterile filaments. × 750. FIG. 19. Carpogonial branch shortly after fertilization of carpogonium. × 750. The cytoplasm of the carpogonium is separating from that of the trichogyne, the chromatophore of the hypogynous cell is breaking down and the cytoplasm has become dense, and sterile filaments are in an active state of formation and growth. The chromatophores of the cells of the carpogonial branch proximal to the hypogynous cell and of the cells of the sterile filaments are not indicated. FIGS. 20–23. Early stages in the development of the gonimoblast. × 750. FIG. 20. Carpo-

tinguishable from a young assimilative filament. Staining also fails to bring out differences. The carpogonial branch first becomes recognizable at the time that the carpogonium is being differentiated. In such stages the terminal cell, or young carpogonium, of a fertile filament (fig. 14) is frequently a little larger than the apical cell of a young assimilative filament of comparable age (fig. 3). At this time, the young carpogonium still contains a chromatophore. Somewhat later (fig. 15), the carpogonium undergoes further enlargement, its chromatophore starts to break down and its cytoplasm begins to assume a homogeneous, dense, darkly-staining quality. Consequently such stages may easily be distinguished from young vegetative filaments.

Figure 16 shows the trichogyne of the carpogonium in an early stage. It will be seen that this carpogonial branch, like those shown in figures 15, 17, and 18, is composed of eight cells. The number of cells varies between five and ten; usually it is seven or eight. When fully developed, the trichogyne is about three times as long as the remainder of the carpogonial branch and projects well beyond the surface of the thallus (fig. 17). The cytoplasm of the trichogyne is homogeneous and faint except at the extreme tip, where it is fairly dense (fig. 17).

Before fertilization, the cells of the mature carpogonial branch proximal to the hypogynous cell begin to initiate sterile filaments (fig. 18). Additional sterile filaments are formed after fertilization has occurred, as will be discussed later.

At the stage indicated in figure 18, the cytoplasm of the hypogynous cell also begins to assume a dense, darkly-staining quality. Such a change has also been reported by Butters as occurring in this cell of the mature carpogonial branch of *T. subnuda*.

Noticeable signs that fertilization has taken place are the separation of the cytoplasm of the carpogonium from that of the trichogyne, a withering of the trichogyne, a breaking down of the chromatophore of the hypogynous cell and a further increase in density of its cytoplasm, and an accelerated production of sterile filaments (fig. 19).

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gonial branch whose fertilized carpogonium has become divided transversely into a small stalk cell and a larger (distal) primary gonimoblast cell. The chromatophore of the cell below the hypogynous cell has degenerated. Those of the other cells of the carpogonial branch and of the cells of the sterile filaments are not indicated. FIG. 21. Part of a carpogonial branch, showing the first division of the primary gonimoblast cell. The chromatophores of the cells of the sterile filaments and of the cells of the carpogonial branch proximal to the cell below the hypogynous cell are not indicated. FIG. 22. A young gonimoblast and part of the carpogonial branch and its sterile filaments. The unstippled cells contained chromatophores while those of the other cells had broken down and the cytoplasm had taken on a dense, homogeneous appearance. FIG. 23. Optical longitudinal section of a carpogonial branch and a gonimoblast which is slightly farther advanced than the one shown in figure 22. The five lower cells of the carpogonial branch and the cells of the sterile filaments issuing from some of them still contained chromatophores.

The gonimoblast-producing function of the fecundated carpogonium next becomes evident. In *T. Requienii* the gonimoblast is initiated by a transverse division of the carpogonium. The gonimoblast develops from the distal of the two cells so formed. This primary gonimoblast cell is always larger than the lower so-called stalk cell (fig. 20).

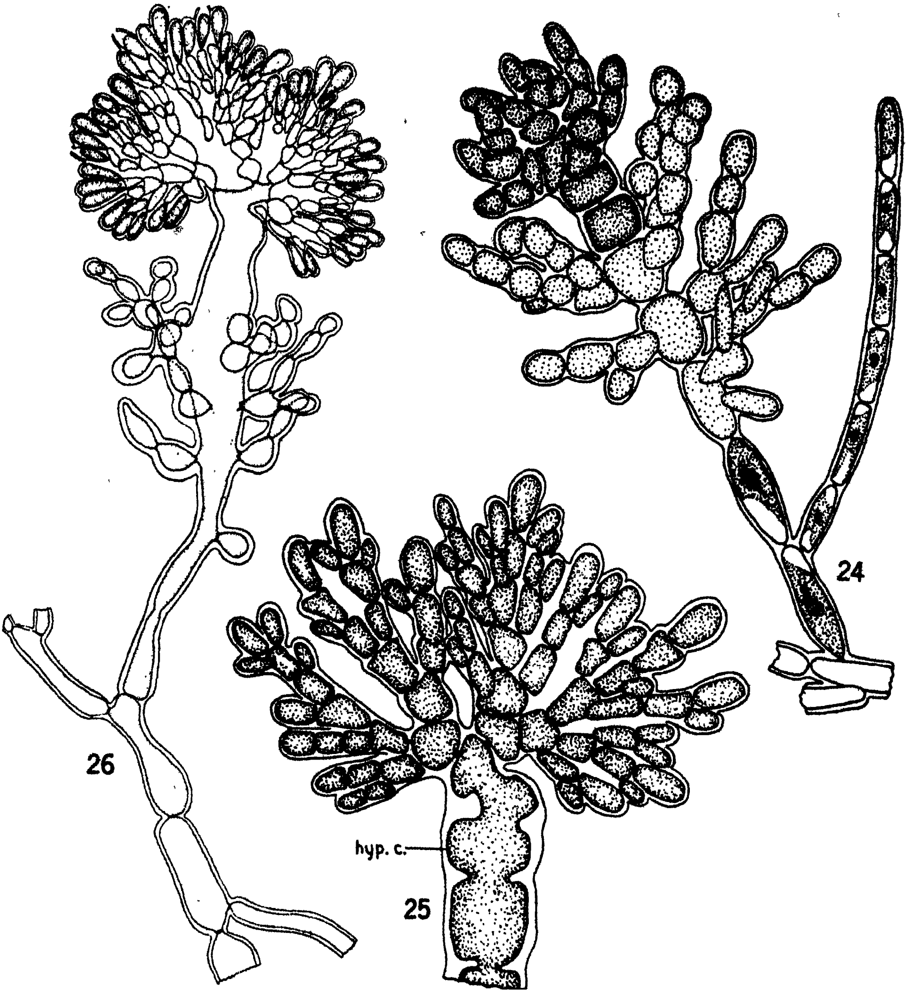
The stalk cell undergoes no further division, while the primary gonimoblast cell by division gives rise to the gonimoblast. The first division is always by a wall which is oblique with reference to the preceding cleavage plane (fig. 21). According to Butters, the first division of the primary gonimoblast cell of *T. subnuda* is by a tranvserse wall. His figures illustrating this are not entirely convincing but if this is so, we have another feature whereby *T. subnuda* could be distinguished from *T. Requienii.*

The further development of the gonimoblast is illustrated in figures 22–26. It will be seen that the derivatives of the primary gonimoblast cell form a globular aggregation of cells (figs. 22, 23), which serve as the starting points of radiating, branched gonimoblast filaments (fig. 24). The terminal cells of these are transformed into carposporangia (figs. 25, 26).

Concurrently with the growth and development of the gonimoblast, a number of striking changes take place in the cells of the carpogonial branch and of the sterile filaments.

Starting at the distal end, there is a progressive degeneration of the chromatophore of the cells of the carpogonial branch and an increase in density of their cytoplasmic content. As has been pointed out, one of the early signs that fertilization has occurred is the breaking down of the chromatophore of the hypogynous cell and an accompanying increase in density of its cytoplasm (fig. 19). In the stages shown in figures 20 and 21, this secondary effect of fertilization had advanced to the cell below the hypogynous cell. In those depicted in figures 22 and 23, it had progressed to the second cell and in that shown in figure 24 to the third cell proximal to the hypogynous cell. Ultimately, when the gonimoblast approaches maturity, this change is observed to have taken place in all the cells of the carpogonial branch; and at times even the supporting cell will have been affected (fig. 26).

During the later phases of maturation of the gonimoblast, the cells of the carpogonial branch undergo another conspicuous change. There is first a gradual widening of the pit-connections between them. This change, like the one described above, takes place in a progressive sequence, starting at the basal cell of the gonimoblast and extending downward to the lowermost cell of the carpogonial branch. Thus, in advanced stages, it is found that the originally narrow pit-connections have become wide canals (fig. 25). In such stages, it is still possible to recognize the limits of the individual cells. But later, when the gonimoblast is full-grown, a complete coalescence of the cells will result in the establishment of a large fusion or placental cell (fig. 26). In addition to the cells of the carpogonial branch, this cell incorporates the stalk cell, the basal cells of the gonimoblast and a few of the cells of the sterile filaments. At times the lowermost cell or two of the



FIGS. 24–26. *Trichogloea Requienii.* FIG. 24. Optical longitudinal section of a carpogonial branch and a young gonimoblast. × 750. In the solidly stippled cells the chromatophore had degenerated. FIG. 25. Almost mature gonimoblast with carposporangia in an early stage of formation. × 750. FIG. 26. Mature gonimoblast and its placental cell. × 360. hyp. c., hypogynous cell.

carpogonial branch do not participate in the formation of the placental cell.

It is of interest that a similar fusion-cell is neither mentioned nor illustrated by Butters as occurring in *T. subnuda*, and to judge from his figure 16, which is of a mature gonimoblast, it seems reasonably safe to conclude that actually a placental cell is not formed in this species. If this is so, the absence of a fusion-cell in *T. subnuda* would not only be an additional but a very clear-cut feature distinguishing it from *T. Requienii.* The likelihood of this difference receives indirect support from the fact that exactly such a distinction obtains between species of the related *Helminthocladia.* Here a fusion-cell is formed in *H. Papenfussii* (Martin 1939) but not in *H. calvadosii*[2] (Kylin 1930).

Finally, with respect to the post-fertilization changes, it is necessary to consider the growth, function and ultimate fate of the sterile filaments.

It was mentioned earlier that, previous to fertilization, the cells of the mature carpogonial branch proximal to the hypogynous cell begin to initiate sterile filaments (fig. 18)[3] and that additional ones are formed after fertilization (fig. 19). During the earlier phases of development of the gonimoblast, these filaments through growth and branching give rise to a loose aggregation of cells about the carpogonial branch (figs. 20–24).[4] At first the cells are provided with a chromatophore, but in correlation with the growth of the gonimoblast there occur a disintegration of the chromatophores and an increase in density of the cytoplasm (figs. 22–24). It will be recalled that similar changes take place in the cells of the carpogonial branch during these phases of development.

According to Butters, sterile filaments are not formed in *T. subnuda* previous to fertilization. However, this point requires substantiation inasmuch as he (Butters 1903, p. 18) states that "No entirely mature and unfecundated procarps were seen." In *Nemalion multifidum* (Kylin 1916, p. 265) the sterile filaments begin to appear, as in *T. Requienii,* before fertilization has been effected. With respect to the position of these filaments, it may be noted that *Nemalion* and *Trichogloea* are the only genera of Helminthocladiaceae in which they arise from the cells of the carpogonial branch. In other genera they either spring from cells in the immediate vicinity of the carpogonial branch or are entirely lacking. Their identical position in

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[2] The specific epithet of *Helminthocladia calvadosii* (Lamour.) Setchell is customarily written with a capital "C." This is not necessary, because the name-bringing synonym *Dumontia calvadosii* Lamouroux (in Duby 1830, p. 941) commemorates the French department of Calvados. The species was first mentioned as a *nomen nudum* by Lamouroux in volume 5 (1824) of "Dict. Class. Hist. Nat." (Not "Dict. Hist. Nat.," as sometimes cited.)

[3] Pilger (1908, fig. 1) illustrates a carpogonial branch of *T. Requienii* in which the hypogynous cell bears a sterile filament. Since his figures are rather diagrammatic, one may question the accuracy of this delineation. In *T. subnuda* they are not formed by the hypogynous cell (Butters 1903).

[4] Schmitz (1896, fig. 203c) has illustrated the sterile filaments of *T. Requienii* as extending well beyond the gonimoblast. However, his figure is so reminiscent of the condition in *Helminthora divaricata,* as illustrated by Thuret and Bornet (1878, pl. 32, figs. 1, 9, 10), that it probably is representative of this species. Neither Pilger (1908) nor Børgesen (1942) found the filaments to extend beyond the base of the gonimoblast.

Nemalion and *Trichogloea* is further evidence in favor of the belief that these two genera are more closely related to each other than to other genera of Helminthocladiaceae.

The sterile filaments of Helminthocladiaceae have usually been regarded as performing a kind of protective role and have frequently been designated as involucral filaments. Although this may conceivably be their function in certain species of *Helminthocladia* and *Liagora* such is not the case in *Trichogloea*. Here, as in *Nemalion* and certain other Nemalionales (cf. Kylin 1937), the sterile filaments constitute a nurse tissue which supplies the gonimoblast with nutrient materials. This is particularly clear from a study of advanced stages of the gonimoblast. In such stages (fig. 26) it is observed that the originally narrow pit-connections of the sterile cells have become wide canals, the cells have lost their dense content, and the walls have undergone gelatinization. Old stages give the impression, moreover, of having suffered a loss of sterile cells (compare figs. 24 and 26), which suggests a possible disintegration of some of the cells after the complete absorption of their content by the placental cell and gonimoblast.

As has been mentioned, a few of the lowermost sterile cells become incorporated in the placental cell. If the carpogonium is not fertilized, the sterile filaments of *T. Requienii* develop into ordinary assimilative filaments.

Monosporangia, such as has been described by Svedelius (1917) for *Helminthora divaricata* and by Abbott (1945) for *Liagora farinosa* were not observed.

Comparison of the Genera of Helminthocladiaceae. In the foregoing pages comparison was repeatedly made between *Trichogloea* and its closest ally, *Nemalion*. Attention was also drawn to certain points of agreement with or departure from other related genera. It now seems desirable to make a somewhat comprehensive comparison of all genera of Helminthocladiaceae which have been investigated.

In addition to *Trichogloea* and *Nemalion*, this family, as now delimited, includes the following eight genera: *Helminthocladia*, *Helminthora*, *Liagora*, *Dermonema*, *Cumagloia*, *Ardissonea*, *Endosira*, and *Dorella*. The last five are monotypic.[5]

Detailed developmental studies have been made of representatives of seven of the genera. Nothing or at best very little is known concerning the development of *Ardissonea*, *Endosira*, and *Dorella*,[6] and they consequently have to be left out of the following discussion.

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[5] The genus *Dermonema* used to be credited with two species, *D. dichotomum* and *D. gracile*, but Weber-van Bosse (1921) has shown that these binomials apply to the same plant, whose name should be *D. gracile* (Mert.) Schm. However, it was recently established by Børgesen (1942) that the correct name was *D. Frappieri* (Mont. & Millard) Børg.

[6] *Dorella* was described by Weber-van Bosse (1921) from a plant from the East Indies, which she distinguished from *Helminthocladia* by its lack of sterile filaments about

In agreement with the majority of Nemalionales, the family Helminthocladiaceae is composed of forms that are haplobiontic. Although differing in detail the genera of this family also show close anatomical correspondence. In all of them the thallus is multiaxial and the assimilative tissue is in the form of radially disposed, branched filaments which issue from the central strands. In *Liagora* and *Trichogloea* the thallus is lime-incrusted.

As to the male reproductive organs, there are differences in the position and arrangement of the antheridia and their mother-cells on the assimilative filaments, but here again a good deal of agreement obtains among the genera.

Significant differences exist, however, with respect to the position and nature of the carpogonial branch and the development of the gonimoblast and associated structures.

As has been pointed out, the carpogonial branches of *Nemalion* and *Trichogloea* are modified assimilative filaments. In the other genera, with the possible exception of certain species of *Liagora,* they are formed as specialized, accessory filaments by cells of the assimilative tissue. (In *Dermonema* they occur on the inner, colorless cells of the assimilative tissue system; Svedelius 1939.) To judge from the illustrations of Yamada (1938, pp. 30–34) it seems likely that in the section *Mucosae* of *Liagora* the carpogonial branch is a modified assimilative filament.

With respect to the early development of the gonimoblast, it is to be noted that this structure develops from the distal of the two cells formed in consequence of the first division of the fertilized carpogonium in *Trichogloea, Nemalion* (Kylin 1916), *Helminthora* (Thuret and Bornet 1878; Kurssanow 1909; Kylin 1928) and *Liagora* (Kylin 1930), while in *Helminthocladia* (Kylin 1930; Martin 1939) both the first-formed cells participate in the production of the gonimoblast. In *Dermonema* (Svedelius 1939) and *Cumagloia* (Gardner 1917; Kylin 1928; Smith 1938) gonimoblast filaments issue directly from the sides of the carpogonium. No transverse division of the carpogonium occurs here. (In *Dermonema* the fertilized carpogonium first establishes a connection with the supporting cell.) The mature gonimoblast is a comparatively compact, globose aggregation of cells arranged in filaments in all genera excepting *Dermonema* and *Cumagloia,* in which it is a diffuse, filamentous structure.

The formation or non-formation of a placental cell is an unstable feature which in certain instances even varies in species of the same genus. Thus a fusion-cell is formed in *Trichogloea Requienii* (fig. 26) but apparently not

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the gonimoblast, its small stature, and its unbranched thallus. Inasmuch as Kylin (1930) has shown that one of the European species of *Helminthocladia* lacks sterile filaments and since size and the absence or presence of branching are characters of questionable generic value, it becomes doubtful if *Dorella* should be retained.

in *T. subnuda* (Butters 1903, fig. 16). In *Helminthocladia Papenfussii,* Martin (1939, figs. 20, 21) observed a well-developed placental cell while such a cell, according to Kylin (1930), is not formed in *H. calvadosii.* Although a placental cell is formed in *Nemalion multifidum* (Kylin 1916) this, to judge from the figures of Børgesen (1915–1916), is not the case in all species of this genus. In *Liagora viscida,* Kylin (1930) observed the formation of a fusion-cell, but the figures of Børgesen (1915–1916) and Yamada (1938) suggest that such a cell is not formed in certain other species of *Liagora.* Only one species of *Helminthora, H. divaricata,* has been thoroughly studied and in it a placental cell is not formed (Kylin 1928). According to Smith (1938), a partial coalescence of the cells of the carpogonial branch occurs in *Cumagloia* and from the work of Svedelius (1939) it may be concluded that this is the case in *Dermonema* also.

In regard to the presence or absence of sterile filaments about the carpogonial branch or gonimoblast, there again is a good deal of variation among the genera and in some instances even among species of the same genus. In *Trichogloea* sterile filaments are present. They arise from the carpogonial branch and begin to be formed at least in *T. Requienii* before fertilization has taken place. The same is true of *Nemalion* (Kylin 1916). In these genera, the filaments have no protective value but function as a nurse tissue to the gonimoblast. In *Helminthora* sterile filaments are also formed. They are initiated after fertilization has occurred, and spring not from the cells of the carpogonial branch but from the two vegetative cells immediately above the supporting cell (Kylin 1928). According to Fritsch (1945, p. 614) the filaments arise from the second and third cells of the carpogonial branch. This, however, is a misinterpretation of the statement and figures of Kylin. The sterile filaments of *Helminthora* perform a protective as well as a nutritive function (Kylin, *op. cit.*).

In *Helminthocladia* sterile filaments of a protective kind are present in the South African *H. Papenfussii* (Martin 1939). They are formed after fertilization has taken place and arise from the vegetative cell immediately above the supporting cell. In the European *H. calvadosii*, on the other hand, sterile filaments are not formed according to Kylin (1930). The observations of Kylin are at variance with those of Schmitz (1896) and Rosenvinge (1909), who also worked with European material. Schmitz does not specify the species upon which his observations were made, but Rosenvinge studied *H. purpurea,* which is regarded as synonymous with *H. calvadosii.*[7] Martin (*op. cit.*) has suggested that Kylin, who studied material from the Atlantic coast of France, may have had a species which was different from that studied by Schmitz and Rosenvinge. (Rosenvinge's material came from Denmark.) This seems very likely, especially since *Helminthocladia* is represented in Europe by a second species, *H. Hudsoni;* and according to Hamel (1930) these species at times closely resemble each other.

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[7] Rosenvinge describes the sterile filaments as issuing both from cells of the carpogonial branch and cells of the supporting filament. Their origin from the carpogonial branch is in need of substantiation.

Sterile filaments do not occur in *Liagora viscida* (Kylin 1930), but filaments of a protective kind are formed from the vegetative cell (or cells ?) below the supporting cell in a variety of species of *Liagora* (cf. Børgesen 1915–1916; Yamada 1938). *Cumagloia* entirely lacks sterile filaments (Kylin 1928), and they apparently are not formed in *Dermonema* either (Svedelius 1939).

On the basis of its diffuse gonimoblast, Schmitz in 1896 erected for *Dermonema* the subfamily Dermonemeae. If this subfamily is to be retained, it is clear from the investigations of Gardner (1917), Kylin (1928), and Smith (1938) that *Cumagloia* also is to be assigned to it.

From his recent study of *Dermonema*, Svedelius (1939) is inclined toward elevation of the Dermonemeae to the status of family. However, as is apparent from the preceding comparisons, *Dermonema* and *Cumagloia* show so many features of correspondence with other Helminthocladiaceae, that there seems to be little justification for separation even as to subfamily.

In these two genera, the gonimoblast is formed by the entire carpogonium instead of as in the majority of other genera by the distal of the two cells resulting from its first division. However, in *Helminthocladia* the entire carpogonium also operates in the production of the gonimoblast, even though in some species it first divides by a transverse wall.

In *Helminthocladia*, as in the majority of Helminthocladiaceae, the mature gonimoblast is a compact mass of cells. In *Dermonema* and *Cumagloia*, on the other hand, it is a diffuse structure. Inasmuch as the gonimoblast of these three genera is initiated in much the same way, that is, from the entire carpogonium, it would seem that the diffuse condition in *Dermonema* and *Cumagloia* as contrasted with the compact state in *Helminthocladia* is to be looked upon as primarily a difference of form.

The condition in *Dermonema* and *Cumagloia* has parallels, moreover, in the related family Batrachospermaceae. Here a diffuse gonimoblast occurs in *Sirodotia* (Kylin 1912; Skuja 1931a) and in *Nothocladus* (Skuja 1934), and what is even more significant, in at least one species of *Batrachospermum, B. orthostichum* (Skuja 1931b), a genus which is otherwise characterized by a compact gonimoblast.

The evidence at hand thus seems to favor retention of *Dermonema* and *Cumagloia* within the family Helminthocladiaceae.

SUMMARY

Although the order Nemalionales is better known than any other order of red algae in regard to the development of the gonimoblast, a number of

outstanding gaps remain. One of the genera of the family Helminthocladiaceae of which but little is known is the tropical *Trichogloea.*

The material for the study of this genus was secured in Hawaii. The reasons for identifying the plants with *T. Requienii* are discussed and an outline is given of the history of the genus and of the geographical distribution of its three species.

As in *Liagora,* the thallus is lime-incrusted. Structurally it agrees with other Helminthocladiaceae. That is, the thallus is composed of a central tissue of intertwined, branched, colorless filaments, from which issue radiating, branched, assimilative filaments. Hairs grow out from the terminal and rarely the subterminal cells of the assimilative filaments.

Ordinarily, *T. Requienii* is dioecious, but occasional plants are monoecious.

The antheridia are formed on the distal, subterminal cells of the assimilative filaments.

The majority of carpogonial branches are formed in the younger parts of the thallus. As in *Nemalion,* the carpogonial branch is a modified assimilative filament. Before fertilization, the cells of the carpogonial branch proximal to the hypogynous cell begin to form sterile filaments, the chromatophore of the carpogonium degenerates, and its cytoplasm becomes homogeneous and dense.

After fertilization, the carpogonium divides by a transverse wall. The proximal of the two cells so formed, the stalk cell, undergoes no further division while the distal cell, the primary gonimoblast cell, by division gives rise to the gonimoblast. When mature, the gonimoblast consists of a globose, comparatively compact, aggregation of cells arranged in filaments. The terminal cells of these become transformed into carposporangia.

During the early phases of development of the gonimoblast, there is an accelerated production of sterile filaments by the carpogonial branch. These filaments function as a nurse tissue to the gonimoblast.

Concurrently with the development of the gonimoblast there also occurs a degeneration of the chromatophore of the cells of the carpogonial branch and an accompanying increase in density of the cytoplasm. In later stages there is a widening of the pit-connections between these cells, which results, ultimately, in a complete coalescence of the cells and the establishment of a large placental cell.

Finaly, a comparison is made of the genera of the Helminthocladiaceae with particular reference to the position and nature of the carpogonial branch and the development of the gonimoblast and associated structures. The evidence at hand shows that *Trichogloea* and *Nemalion* are more closely related to each other than to other genera of this family. The criteria in support of the suggested elevation of the subfamily Dermonemeae, which includes *Dermonema* and *Cumagloia,* to the rank of family are analyzed. It is concluded that there is not at present sufficient ground for separation even as subfamily.

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CYTOGENETICS OF DATURA FASTUOSA L.

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INTRODUCTION[1]

Datura has become classic amongst the cytologists owing to the sustained work carried on for years by Blakeslee and his collaborators. They have been able to isolate nearly 100 distinct and different races of *Datura,* now known as prime types. These races of *Datura* have been shown to have originated principally through segmental interchange. Of 53 prime types, 5 have been found occurring in nature, each differing from the others with respect to particular interchange.

In India, *Datura stramonium* and *Datura arborescens* occur mainly in Sikkim and the surrounding localities. The latter species occurs also in Khasi Hills. Another species, *Datura fastuosa,*[2] closely related to *Datura stramonium,* occurs throughout the plains of India. The two varieties of *Datura fastuosa,* commonly known as the white and black Daturas, are common weeds of waste places throughout India. The two varieties produce forms in nature which differ mainly with respect to leaf, stem, and flower characters. The two strains are distinguished mainly by the presence or absence of anthocyanin pigment in the body of the plant. In the black strain, the stem is black, as are also other parts of the body.

Gates (1942), in his review on the nucleolus and related structures, cited the condition in *D. stramonium* as an exceptional case where, according to Satina, Bergner and Blakeslee (1941), a high number of satellites has been observed. This observation apparently contradicts the theory of numerical correspondence between satellited chromosomes and the number of nucleoli. In the light of the above report, a study of the chromosome-nucleolus relationship in the related species *D. fastuosa* was undertaken.

As has been mentioned already, a large number of forms of this species occur in nature. An examination of these forms is expected to throw some light on the cytological basis of such variation, as will also be evident from the statement made by Dr. W. Burns (1944) in his presidential speech on "Genetics, taxonomy and ecology" which we quote below: "The common weed of waste places, *D. fastuosa*, is found in several forms differing in size and shape of leaf and flower. I should not wonder if a careful study of this species should yield results of a similar nature to those obtained by Blakeslee in his classic work on *D. stramonium* in America."

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Dr. Gates has also made certain minor modifications in the manuscript, and, because of the time which would be lost by transmission to India, has read the proofs.

[2] This is the name commonly used in India for *D. metel.* See Bergner 1943.

MATERIAL AND METHODS

The material for the present investigation was obtained from the following: *Datura fastuosa* (black) and *Datura fastuosa*, var. *alba* (white). Morphological variations are met with in both varieties, but in this respect the latter shows a greater degree of variation than the former. The irregularities are mainly manifested in the shape, size, color, and arrangement of the leaves as well as in flower color. The black variety exhibits variation only as regard the different shades of blackness on the vegetative organs and in floral parts. In some, it is present in higher degree, giving the stem a jet black color, while in others the deep purple color is restricted to the nodes. Between the two extremes are intermediate types.

In both the above the fixing of somatic chromosomes in root-tip cells presented considerable difficulties. Root-tips collected from established seedlings did not prove to be fruitful, as they were very slender and as good somatic plates with properly fixed chromosomes could not be obtained from them. Fully imbibed mature seeds were first kept in a cold room having a constant temperature of 74° F; after 2 days, these were placed again in a warm place. This change of temperature was found to give the necessary stimulus for breaking the dormancy, and healthy root-tips were then obtained from the germinating seeds. Several fixatives with various proportions of the ingredients have proved to be unsatisfactory in this case, showing once again why the morphology of the somatic complement could not be made out previously. Blakeslee and his collaborators have obtained good results in fixing the root-tips of *D. stramonium* in a fluid containing 5 parts of 1 % chromic acid and 4 parts of 10 % formalin, but in the present material this fluid has proved to be of little use. Best results were, however, obtained by fixing the root-tips between 12 noon and 2 p.m. in a fluid containing 4 parts of 1 % chromic acid and 7 parts of 10 % formalin. After the usual paraffin embedding of the root-tips, sections were cut 16 μ thick. Premordanting overnight in Lewitsky's fluid (1:1) before crystal violet staining gave best results. For the study of meiotic chromosomes, Flemming's medium fluid gave best results. The paraffin sections of the flower buds were cut 20–22 μ thick and a premordanting overnight in 1% chromic acid became necessary before crystal violet staining. Permanent smear preparations were also made, for which the material was fixed in Belling's modification of Navashin's solution. For the study of nucleoli in the dyad and tetrad stages and in the root-tip cells Feulgen-light-green staining was applied. After a series of attempts, fairly good results were obtained by first mordanting the preparations overnight in the Belling-Navashin "A" solution before proceeding with the Feulgen-light-green staining. The carbonate mordant (saturated solution of sodium carbonate in 80% alcohol) was used as differentiating solution for the light green stain (see Semmens and Bhaduri 1939, 1941).

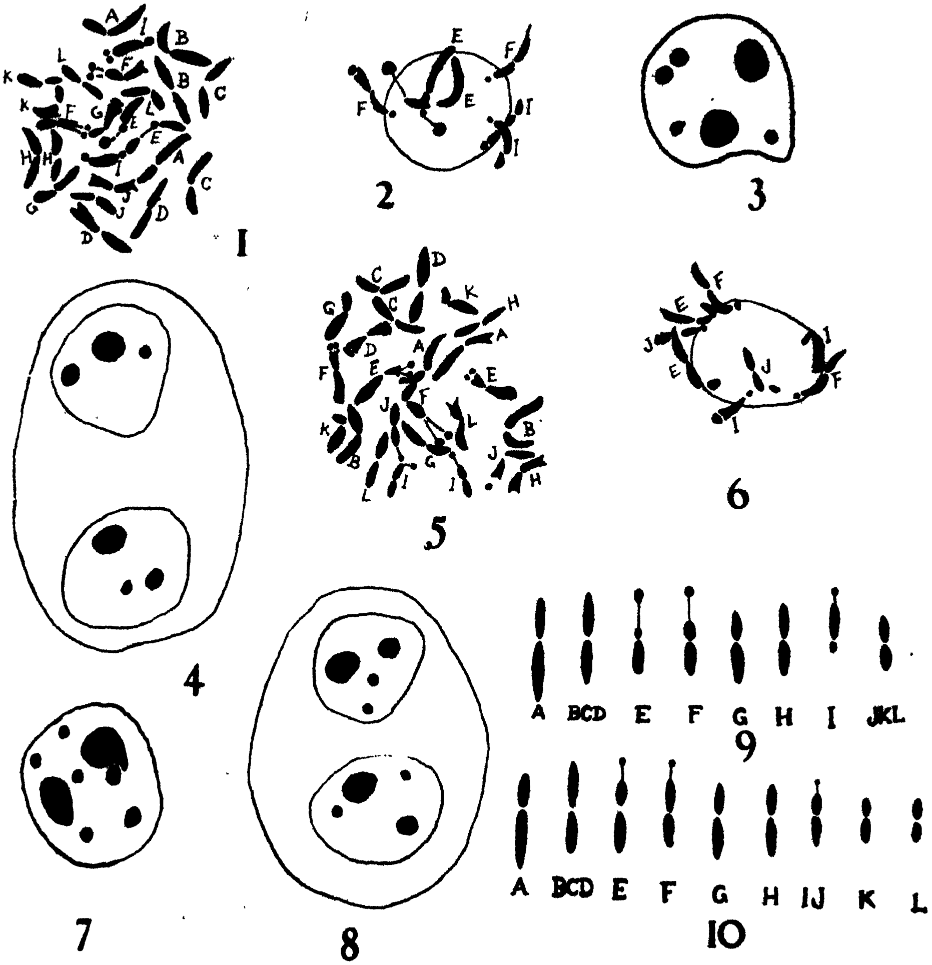
The figures were drawn at a table magnification of approximately 3600 times, using a compensating eyepiece No. 18 and a 1.3 apochromatic objective.

DATURA FASTUOSA (BLACK)

The common black *Datura, D. fastuosa,* has 24 chromosomes in the root-tip cells. The number corresponds with the previous reports made by Belling and Blakeslee (1923), Vilmorin and Simonet (1928), Bhaduri (1938), and Raghavan and Srinivasan (1942). From a critical observation of a large number of well fixed plates, it was found that the chromosomes of this species could be classified into eight different types, clearly distinguishable from each other by their size differences and the relative positions of primary and secondary constrictions. The eight types (figs. 1, 9) are as follows.

1. A pair of long chromosomes with submedian primary constriction (AA).
2. Three pairs of long chromosomes with median constriction (BB, CC, DD).
3. A pair of medium-sized chromosomes with nearly subterminal primary constriction and a big satellite attached at the shorter arm (EE).
4. A pair of medium-sized chromosomes with almost median primary constriction and a satellite attached to one of the arms (FF).
5. A pair of medium-sized chromosomes with submedian primary constriction (GG).
6. A pair of medium-sized chromosomes with median primary constriction (HH).
7. A pair of small chromosomes with subterminal primary constriction and a satellite attached to the longer arm (II).
8. Three pairs of small chromosomes with median primary constriction (JJ, KK, LL).

In the prophase stage of root-tip cells, six chromosomes were seen distinctly attached to the nucleolus (fig. 2). The morphology of these chromosomes corresponded with the nucleolar chromosomes found in the metaphase plate. Six nucleoli were also seen in the telophase stage of root-tip cells, one pair being big, one pair intermediate, and the other pair small in size (fig. 3). Meiosis in the pollen mother-cells was found to be normal. In diplotene and diakinesis, regular chiasma formation and different configurations due to terminalization were evident (fig. 11). The 12 bivalents seen in metaphase disjoined regularly at anaphase (figs. 12, 13). During the second meiotic division, irregular separation, leading to the formation of 13 and 11 chromosomes at the poles, was observed in a small percentage of mother-cells. Tetrad formation was of the simultaneous type.



FIGS. 1–4. *Datura fastuosa.* FIG. 1. Somatic metaphase plate showing 24 chromosomes including 6 nucleolar ones. FIG. 2. The 6 nucleolar chromosomes attached to the fused nucleolus. FIG. 3. Telophase nucleus showing 3 homomorphic pairs of nucleoli. FIG. 4. Dyad nuclei each containing 3 nucleoli. FIGS. 5–8. *Datura fastuosa* var. *alba.* FIG. 5. Somatic metaphase plate showing 24 chromosomes including 8 nucleolar ones. FIG. 6. The 8 nucleolar chromosomes attached to the fused nucleolus. FIG. 7. Telophase nucleus showing 4 homomorphic pairs of nucleoli. FIG. 8. Dyad nuclei each containing 4 nucleoli. FIGS. 9–10. Idiograms of the two varieties *D. fastuosa* and *D. fastuosa* var. *alba.*

The dyad nuclei often showed the presence of 3 nucleoli in each, one big, one intermediate and the other small in size (fig. 4). It can be stated, therefore, that the big, the intermediate, and the small form three homologous pairs. Amongst these the intermediate and the small nucleoli have been seen to remain adpressed on the surface of their respective chromosomes.

DATURA FASTUOSA VAR. ALBA

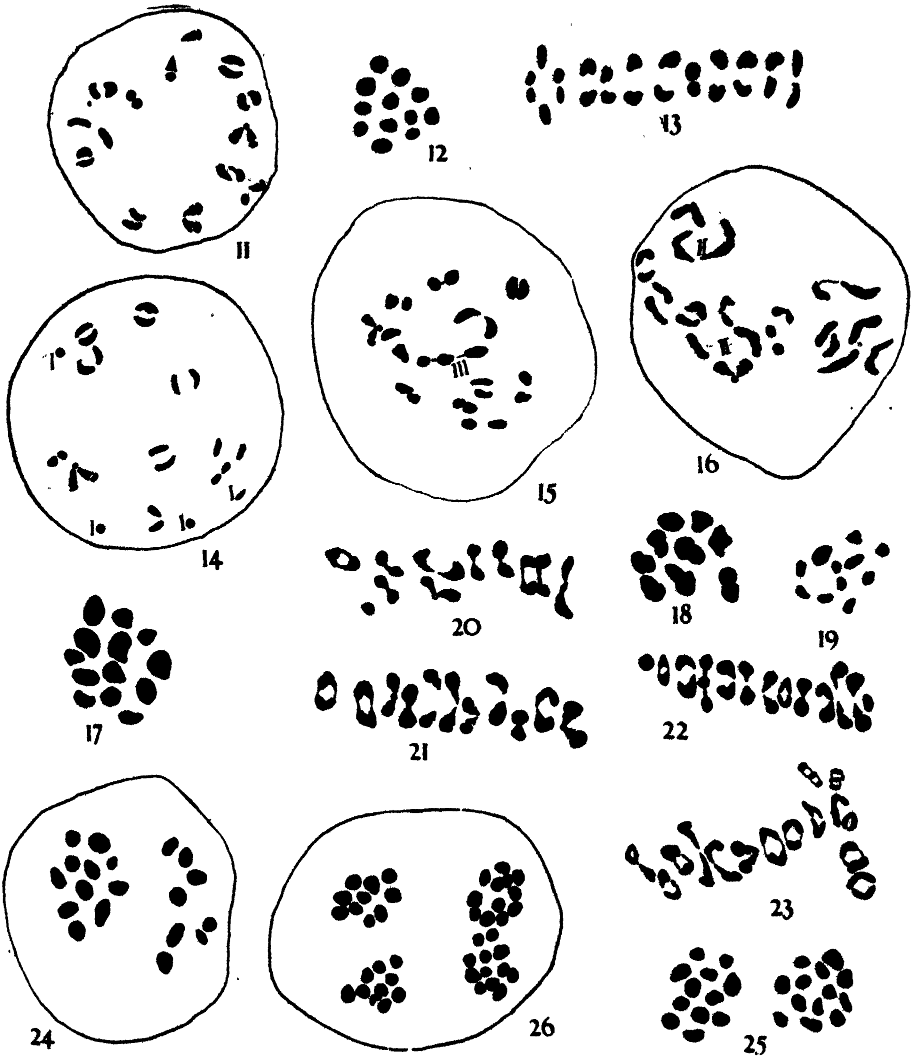
The common white *Datura* has the same chromosome number as the black one. Here the 12 pairs of chromosomes could be classified into 9 different types. The morphology of the chromosomes in this variety has been found to be slightly different from the other. The nine different types were clearly distinguishable from each other by their size and the relative positions of primary and secondary constrictions in the chromosomes. The nine different types are as follows (figs. 5, 10).

1. A pair of long chromosomes with submedian primary constriction (AA).
2. Three pairs of long chromosomes with median primary constriction (BB, CC, DD).
3. A pair of medium-sized chromosomes with nearly submedian primary constriction and a satellite attached at the shorter arm (EE).
4. A pair of medium-sized chromosomes with median primary constriction and a satellite attached at one arm (FF).
5. A pair of medium-sized chromosomes with submedian primary constriction (GG).
6. A pair of medium-sized chromosomes with median primary constriction (HH).
7. Two pairs of short chromosomes with median primary constriction and a satellite attached at one arm (II, JJ).
8. A pair of short chromosomes with submedian primary constriction (KK).
9. A pair of short chromosomes with median primary constriction (LL).

In the prophase stage of root-tip nuclei, eight chromosomes were seen distinctly attached to the nucleolus (fig. 6). The morphology of these chromosomes corresponded with the nucleolar chromosomes observed at the metaphase plate. Eight nucleoli were observed in the telophase stage of somatic nuclei, one pair being big, one pair intermediate, and the other two pairs small in size (fig. 7).

Blakeslee and his co-workers have made a detailed investigation of the meiotic behavior of *D. stramonium*. All the primary trisomics, secondaries, and tertiaries have been found. During the present observation, no prime types or trisomics have been found. Though a large number of plants have been examined, yet all the specimens were found to possess 24 chromosomes in the somatic nuclei. Moreover no ring formation nor the "kite" or "necktie" formations during meiosis, as has been observed by Blakeslee in *D. stramonium* hybrids, were observed.

During meiosis, in the pollen mother cells considerable irregularities of the chromosomes have been observed. Besides the normal occurrence of twelve bivalents and their normal pairing and segregation, different chromosome numbers ranging from 9 to 14 bivalents were observed. Even in



FIGS. 11–13. *Datura fastuosa.* 12 regular bivalents during diakinesis, metaphase, and anaphase, respectively. FIGS. 14–16. Diakinetic nuclei showing 10 bivalents + 4 univalents, 11 bivalents + 1 trivalent, and 14 bivalents, respectively. FIGS. 17–19. Metaphase I showing 13, 9, and 11 bivalents, respectively. FIGS. 20–23. Anaphasic separation of 10 bivalents + 1 univalent, 11 bivalents, 10 bivalents + 1 trivalent + 2 univalents, and 14 bivalents, respectively. FIGS. 24, 25. Metaphase II showing irregular distribution of univalents. FIG. 26. Anaphase II showing a distribution of 10 and 10 and 12 and 12 univalents.

some of the pollen mother-cells with 24 chromosomes, normal pairing was not observed. So, in diakinesis, ten normally paired bivalents and four univalents have occasionally been found (fig. 14). The irregularity in chromosome number was evident in all the stages, including the second division of meiosis. In diakinesis, mother-cells with 9 bivalents, 10 bivalents and 1 univalent, 13 bivalents, 11 bivalents and 1 trivalent, 14 bivalents, 11 bivalents, 11 bivalents and 1 univalent, etc., were distinctly observed (figs. 15, 16). Different configurations due to different degrees of terminalization were also interesting to note. Metaphase plates showing 9 to 13 bivalents with their characteristic size differences have been recorded (figs. 17, 18, 19). In anaphase stage, chromosome numbers ranging from 19 to 26 and univalents and multivalents were also observed (figs. 20, 21, 22, 23). The disjunction of bivalents could be examined more clearly in the smear preparations than in sections.

TABLE 1. *Different types of segregation during anaphase I & II in D. fastuosa var. alba*

Diff. chromosome No. & their pairing found in 1st. div.	No. of times observed in 100 P.M.C. taken at random	No. of univalents at one or both poles during 2nd. div.	No. of times observed in 100 P.M.C. taken at random
12 bivalents	43	12–12	50
13 "	8	10–11	13
9 "	3		
11 "	14	8–11	3
10 "	6	12–11	4
14 "	3	10–10	3
10 bivalents + 1 univ.	3	11	15
11 " + 1 "	3	10	5
9 " + 1 "	5	8	2
12 " + 1 "	4	13	4
10 " + 4 "	5	14	1
10 " + 2 " and 1 triv.	3		

In the second meiotic division also, the irregularities were quite evident and cases were recorded with 13 and 12, 10 and 11, 8 and 11, 12 and 11 chromosomes, etc. in the two metaphase groups (figs. 24, 25). Abnormal numbers after the second meiotic divisions were also observed passing into the tetrad stage (fig. 26). In the present investigation an attempt has been made from a large number of observations to find out the average frequency of the occurrence of different chromosome numbers in the P.M.C.'s resulting from such irregularities. The observations are presented in table 1. From this table it will be evident that nearly 50 per cent of the P.M.C.'s bear irregular numbers.

It is interesting to note that all the irregular types could be seen sometimes within the same anther lobe.

It may be concluded from the above observations that some change in the premeiotic divisions must be responsible for the production of P.M.C.'s with abnormal chromosome numbers. It is quite probable that some of the chromosomes fail to divide at this stage. This will lead to increase and decrease of chromosome numbers at the two poles and thus mother-cells with higher or lower chromosome numbers than the normal haploid number will be formed. If it is assumed, for instance, that of 24 chromosomes 21 undergo normal division and the remaining 3 do not divide fully, i.e., the two chromatids remain attached by their centromere, move to one pole and separate later, then this will lead to the formation of one daughter-cell with 21 chromosomes and the other with 27 chromosomes. Such irregular premeiotic division will, as a rule, produce duplication of some of the chromosomes in some mother-cells and deficiency of some other chromosomes in the same number of mother-cells. Thus the occurrence of multivalents in some and univalents in other P.M.C.'s can easily be explained. Further, if the non-dividing chromosomes be equally shared by the two daughter-cells, abnormalities in the P.M.C. bearing the normal $2n = 24$ chromosome number may result. For example, if of 24 chromosomes 4, viz., A, B, C, and D, fail to divide during anaphase, and if A and B move to one pole and C and D to the other, then one of the daughter-cells, though having 24 chromosomes, will have the duplicated sets of A and B chromosomes and the other daughter-cell will have the duplicated set of C and D chromosomes. Consequently in the former case C and D and in the latter case A and B respectively will be deficient. Furthermore, occurrence of univalents in large numbers in a nucleus also indicates the presence of extra chromosomes which have failed to pair during meiosis.

The tetrad formation is of simultaneous type and the arrangement of tetrad nuclei in different planes of the mother-cell was quite evident. Irregularities in tetrad formation were also observed and "linear tetrads" of spores have occasionally been found. It was observed in some P.M.C.'s that late in the season variations in temperature were accompanied by the occurrence of several, as many as eight, free nuclei, indicating the extreme susceptibility of the plant to temperature fluctuation. Similar instances have been reported in *Hyacinthus* (de Mol 1923), *Triticum* hybrids (Kihara & Lilienfeld 1936), *Kniphofia* (Moffett 1932), *Tradescantia,* and *Gaura* species (Bhaduri 1941, 1942a).

The dyad nuclei show 4 nucleoli in each nucleus, one being big, one intermediate, and the other two small and similar in size (fig. 8). The two small nucleoli were seen closely appressed against the respective nucleolar chromosomes. It can be stated therefore that the big, the intermediate, and the two small nucleoli form 4 homologous pairs.

Pollen grains are of the same type as found in the black variety, but in this variety pollen grains with different sizes and shapes (small, medium, and large), showing also partial abortion, were not infrequently met with. The percentage of abortive grains (15 to 18) was not so high as the irregularities of chromosomes in P.M.C. (as many as 50 per cent of the mother-cells) during meiosis would suggest (cf. table 1). Presence of pollen grains of varying sizes can be explained on the basis of chromosome deficiencies and balance (Darlington 1929, Bhaduri 1942b). Attempts were made to find out the time of division of the pollen grains but satisfactory results have not yet been obtained.

DISCUSSION

Although extensive work has been done in *D. stramonium* by Blakeslee and his co-workers, very little is known about the allied species *D. fastuosa*, the common weed of waste places in India. As has been pointed out in the introduction to this paper, Gates (1942) in his review has mentioned that in *D. stramonium* a high number of satellited chromosomes, as many as seven in the haploid plant, have been found by Satina, Bergner and Blakeslee (1941). The latter authors have, however, not examined or counted the number of nucleoli in this species. In *D. fastuosa* it will be found from the present investigation that an exact correlation exists between the maximum number of nucleoli and the number of satellited chromosomes. The two varieties of *D. fastuosa* differ, however, from each other in the number of nucleoli and the number of satellited chromosomes present, the maximum number of nucleoli and nucleolar constrictions found in the somatic complement in the two varieties being 6 and 8 respectively. A corresponding number of nucleoli in the telophase stage of root-tip cells, in dyad and tetrad nuclei has also been found. This observation is also confirmed from the number of attachments of chromosomes to the fused nucleolus of the somatic prophase stage. It is interesting to note that the morphology of the somatic chromosomes, excepting the satellited ones, is very similar in the two species *D. stramonium* and *D. fastuosa*.

In view of the above observations, it may be suggested that a critical re-examination of *D. stramonium* with respect to the maximum number of nucleoli and satellited chromosomes is desirable.

It has been generally assumed that a true diploid species should have a pair of homomorphic nucleoli in the somatic nuclei (Bhaduri 1943). Increase in the number of nucleoli or the presence of size differences between the nucleoli in a species has been interpreted to be due to numerical and secondary polyploidy, segmental interchange between nucleolar and non-nucleolar chromosomes (Bhaduri 1943), and fragmentation of satellited chromosomes (Bhaduri & Bose 1946). Both *D. stramonium* and *D. fastuosa* are generally taken to be true diploid species. Previous observation in *D.*

stramonium and the present work on *D. fastuosa* do not give evidence as to the secondary polyploid nature of the two species. No secondary association between bivalents, a characteristic feature of secondary polyploid plants, has been observed in these two species. There is evidence, however, to show that considerable structural changes of chromosomes have taken place in *D. stramonium*. According to Bergner, Satina and Blakeslee (1933) and later work (Blakeslee et al. 1940), there are 96 prime types of *D. stramonium*, each differing from the parent standard type with respect to one or more interchanges. If such interchanges are involved between nucleolar and non-nucleolar chromosomes, then the origin of a high number of secondary constrictions and nucleoli is expected (McClintock 1934, Bhaduri 1942a).

It will be interesting to know how the prime types differ from the standard *D. stramonium* with respect to the maximum number of nucleoli and satellited chromosomes. Unlike *D. stramonium*, in both the varieties of *D. fastuosa* no evidence of translocation has been obtained from the behavior of meiotic chromosomes in the P.M.C., since no ring of four or "kite" or "necktie" type of formation during meiosis has been observed. In the white strain, as described in the text, a very remarkable irregularity in as many as 50 per cent of the P.M.C.'s during meiosis has been recorded. It has been pointed out, that in the premeiotic mitosis, failure in the division of one or more chromosomes and their subsequent inclusion in the P.M.C. nucleus often leads to the production of spores having either higher or lower numbers of chromosomes than the usual gametic number. Random union of such gametes can not only produce plants having higher or lower chromosome numbers than the normal diploid number ($2n = 24$), but otherwise than in *D. stramonium* we find here a possibility of having species with the normal diploid chromosome number $2n = 24$, at the same time having one or more chromosomes duplicated. If nucleolar chromosomes are involved in such abnormalities then an increase or decrease in the number of nucleoli and satellited chromosomes may easily result. On the basis of this hypothesis, the formation of a ring of four and multivalent formation in *Datura* can also be explained as due to duplication of chromosomes by irregular premeiotic mitosis without assuming previous translocations, as found in many prime types of *D. stramonium*.

It is remarkable that although spores with such irregular numbers have been found in the white strain, *D. fastuosa* var. *alba*, trisomics or plants with higher or lower number of chromosomes appear to be rare. Further, when we assume duplication of one or more chromosomes in the white strain we should also expect multivalent formations during meiosis. During the present observation, however, although a good number of plants have been examined, the percentage of multivalent formation during meiosis has always been found to be very small.

Some explanation of the physical basis of the origin of different forms of *D. fastuosa* can be obtained in the light of the observations made regarding the production of spores having different chromosome numbers and particularly of the origin of spores having the same chromosome number but of different genotypes. As is evident from table 1, about 50 per cent of the P.M.C.'s bear an irregular number of chromosomes. Furthermore, the percentage of abortive grains has been found to be only 20 per cent approximately. Therefore it is quite evident, that about 30 per cent of these spores remain viable with irregular numbers of chromosomes. Whether these different forms of *D. fastuosa* occurring in nature are distinct phenotypes, breeding true to character, or different ecological strains, remains to be proved by breeding experiments. Preliminary experiments in this direction have already been started. In the black strain, where fairly regular behavior of chromosomes has been observed during meiosis, we find also variation, though on a comparatively smaller scale.

SUMMARY

The two varieties of *D. fastuosa*, the black and the white, a common weed of India, differ from each other with respect to the presence or absence of anthocyanin pigment in the body of the plant. The white variety shows a wider range of variation as compared to the black one. A comparative idiogram study of the two varieties has revealed a close similarity between the two, except that in the black variety there are three and in the white there are four pairs of chromosomes with nucleolar constrictions. Corresponding to this, there are three and four homologous and homomorphic pairs of nucleoli present in the two varieties respectively. The present observation is in conformity with the theory of numerical correspondence between the maximum number of nucleoli present in a species, and the total number of secondary constrictions present in the chromosome complement of that species. A re-investigation of *D. stramonium* in the light of the present investigation has been suggested.

In both the varieties normal pairing of twelve pairs of chromosomes has been observed. No evidence of secondary association between bivalents could be obtained. Excepting occasional trivalents, ring formation or other multivalent formations have not been found. While a fairly normal meiotic behavior is present in the black variety, in the white variety a very interesting condition has been observed. Some chromosomes fail to separate in the premeiotic mitosis with the result that mother-cells showing higher or lower chromosome numbers ($n = 9, 10, 11, 12, 13, 14$) than the haploid number are formed. This irregularity leads to duplication or deficiency of some of the chromosomes and consequent univalent and occasional multivalent formations. It has been shown how this type of irregularity may not only lead to the formation of gametes having unequal chromosome numbers but also to gametes having the normal haploid number but of different genotypic constitution. Random and successful union between such gametes provides an explanation of the cause of origin of trisomics, tetrasomics, $2n-1$, and other types, as well as of plants showing the normal diploid number but of different genotypes. These may also differ phenotypically. The wide range of variation found in this variety should be analyzed by breeding experiments in the light of the present observations.

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NOTES ON THE VEGETATION OF SIERRA SUROTATO IN NORTHERN SINALOA

HOWARD SCOTT GENTRY

Sierra Surotato rises in great form up from the coastal plain in northern Sinaloa. Those who ride the rails may look out northeastward in the latitude of Guamuchil (25° 30″ N) and see its blue-distant hulk, often crowned with clouds, and, if the atmosphere is clear, see also the rugged broken rims of rocks and numerous penetrating canyons. I beheld it so in the spring of 1940 and thereafter that distant beauty and the lure of unknown and unsought plants secreted in the mountain fastnesses led me back to visit it in 1941 and again in 1945.

The top elevations of Sierra Surotato range from 6500 to 7500 feet above sea level. It is a coastal outpost of the Sierra Madre Occidental, the main axis of which is carried through Sierra Mohinora in Chihuahua about 40 airline miles eastward. Surotato's position is comparable to that of Sierra de Alamos, classic plant locality in southern Sonora, but its bulk is much greater. Generally in Mexico the inhabitants have local names for mountains and neglect general or inclusive appellations for mountain systems and this is true of the Surotato complex. Sierra Surotato is composed, from north to southeastward, of Sierra Ocurahui, Sierra Surotato, and Sierra Monterrey. The situation is shown on the accompanying map (fig. 1), which should not be assumed as accurate in detail. Since this sierra is not named on any maps I have reviewed, it can serve until measured detail is supplied. Its position is well indicated on the one-to-a-million Map of the Americas, Culiacan quadrangle, published by the American Geographic Society in 1935. My aneroid readings showed the highest peak, Surotato, to be 500 to 600 feet higher than the 2192 m. given on that map. The system is 40 to 50 miles long NE to SE and variously dissected by deep precipitous canyons and intricately ramified by radiating ridges.

The core of the mountain is granitic. It was observed as the common rock in the Tamiapa foothills on the southeast and again through the foothills on the west as far out as San Joaquin. Laid over the granite through high and low elevations are various lavas of various ages and extent. In the higher elevations are both massive and laminated sedimentaries, highly deformed and often metamorphosed. These are strikingly exposed atop Sierra Monterrey (fig. 2). Mainly, however, it is the volcanics that form the rugged cliffs and peaks of the higher elevations, some strongly calcareous as the Peñascos de Pucheros.

Sierra Surotato is relatively wet as attested by the rather numerous epiphytic bromeliads, orchids, lichens, mosses, and the preponderance of mesophytic and tropical species. The rainfall station nearest to Surotato is in Badiraguato, lying in a foothill valley 30 to 40 miles southeast. Its annual average is around 30 inches. That of Sierra de Alamos, about 100 miles north of Surotato, in Sonora is between 20 and 25 inches annual average. With these records (1) and the indications from vegetation we can estimate the higher wetter elevations of Sierra Surotato to exceed 40 inches annually. The season is binary; rains from May to February with a mild drought period in the fall, and long drought through the spring. Occasionally spring rains occur, however, as in March 1940 when it rained heartily for a week, much to the surprise and consternation of the collecting botanists. The copious summer rains are convectional in type, of tropic origin; the more

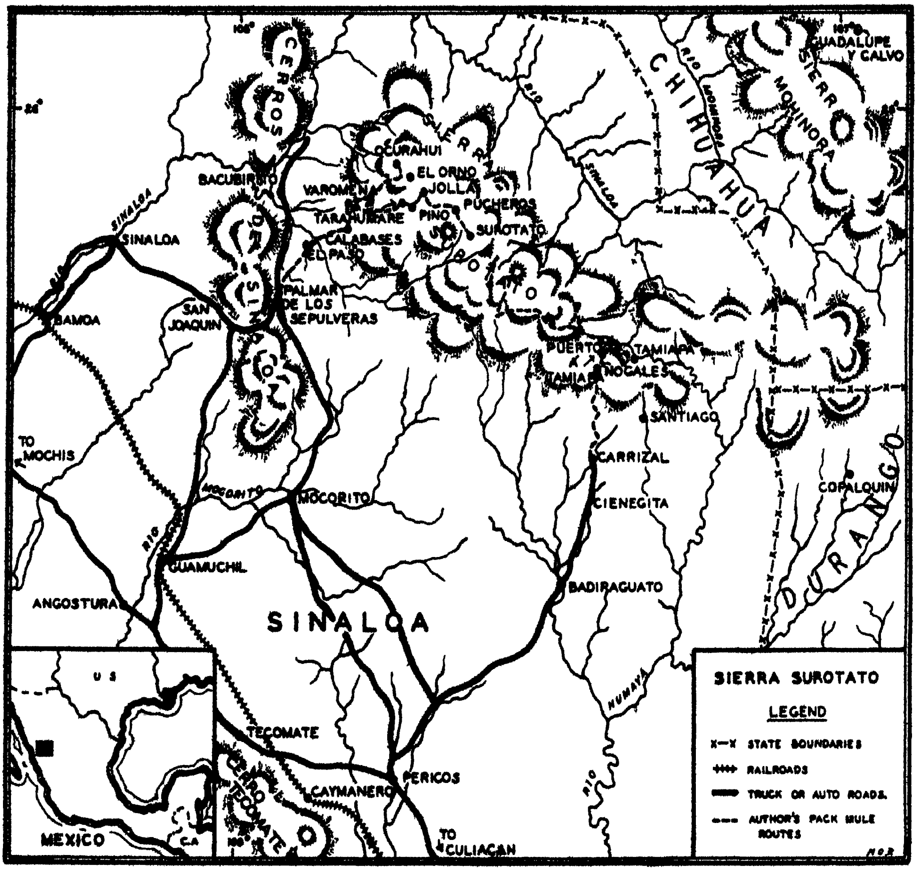

Fig. 1. The Sierra Surotato region. Scale 1: 225,000.

violent storms are known as "chubascos." The "equipatas" (< L.—even feet) are the light even rains of winter.

White clouds that the lowlanders see investing the heights of the mountain are only fog to the mountaineers. This reduces the incidence of sunlight considerably over that due to rain clouds alone, since it may appear both preceding and following diurnal rain hours, and may also occur as ground fog lying in the highland valleys in the early morning. The foggy forest is gloomy and dripping, festooned with hanging mosses, cool, and inhabited only by shade-tolerant species on the northern slopes. Fog is undoubtedly a chief factor in supporting the rich communities of epiphytes and the varied forest of tropical nature

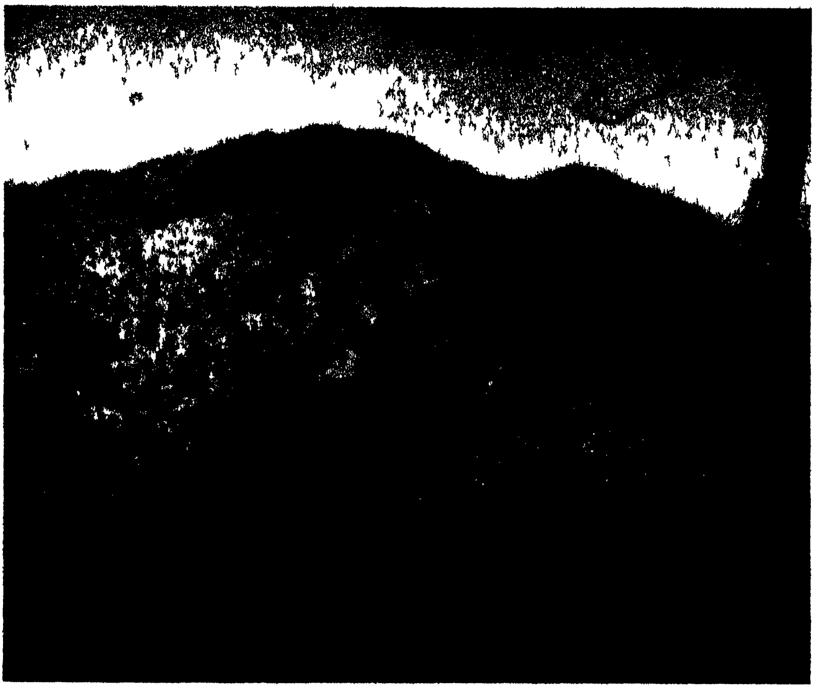

FIG 2. Sierra Monterrey forested with pine and oak; looking north, March 1940 The anticlinal massive sedimentaries dip westward.

Snowfalls are said to be of almost yearly occurrence at Ocurahui and throughout the higher elevations. As reported by the natives, they are light, lie but a little while, and fall in January and February. Yet orchids and *Tillandsia* grow in these elevations of snowfall (fig. 3), suggesting an unexpected tolerance to cold. However, plants were observed in rather spotted occurrence, indicating that they are restricted in these higher elevations to warmer spots conditioned by local features of terrain. The area of snowfall is within the pine zone.

The vegetation of Sierra Surotato has been markedly disturbed by man in a small percentage of the area. Regular planting and cattle are limited to the areas of less rugged terrain. Milpas of beans, squash, potatoes, wheat, and maize, and small orchards of peaches, quinces, apples, and oranges are scattered through the mountain adjacent to the small settlements. There is a small planting or two of coffee in Canyon Tarahumare, the most northerly occurrence of this crop in North America. The opium poppy, *Papaver somniferum*, is scattered in small plots, spring-grown, often following wheat. Though the poppy is dry-farmed, it is preferably planted where it can be irrigated by diverting the small mountain rills. The uncertain spring rains may or may not be sufficient for a good yield of gum. It is a contraband product providing the mountaineers with a ready cash crop. Because of this they are suspicious of strangers and I was once threatened with indefinite detention.

Transient milpas through the past two decades have made serious mutilations of the mountain cover. This is conspicuous through the Canyon de Tarahumare, where even precipitous rocky slopes of 40° to 60° inclination are cut over for only the one or two crops of maize they will produce. Increase in such cuttings is correlated with increase in local population. These natives refuse offers of more arable land in the coastal plain because they prefer to live in their mountain environment, believing that they would suffer and fall ill in the hot lowlands. They are poor and subsist upon an incipient agriculture which would be inadequate for any modern society. The native trees are also felled for local fuel and lumber.

The rancho, Los Pucheros, is remarkable for the degree of comfort and orderliness with which it has been maintained. This is entirely due to an elderly bachelor, now crippled, native of the mountain, who admires and can name every state in our union, although he has spent his whole life upon Surotato. In his pine log buildings with shake roofs he quarters summer vacationists from the hot lowlands. Mostly they make the laborious trip by mule, but airplanes have been landed at the neighboring rancho of El Horno several miles away. The landing strip is a mountain meadow atop the sierra. Landings, however, should not be attempted without first ascertaining the condition of the field.

The natural vegetation of Sierra Surotato is thriving, unusually complex, and covered by slope forests of highly mixed dominants, largely deciduous in the lower elevations, pine-dominated in the upper. The more arid element is found in the Short-tree Forest formation (2) of the lower slopes. Upward in the wetter elevations, 2500–4500 feet, are many intruding tropical species. Here the formation is more nearly a tropical deciduous rainforest with an increase in the density of shrub species over that found in typical Short-tree Forest. Tropical mesophytes are best represented in the

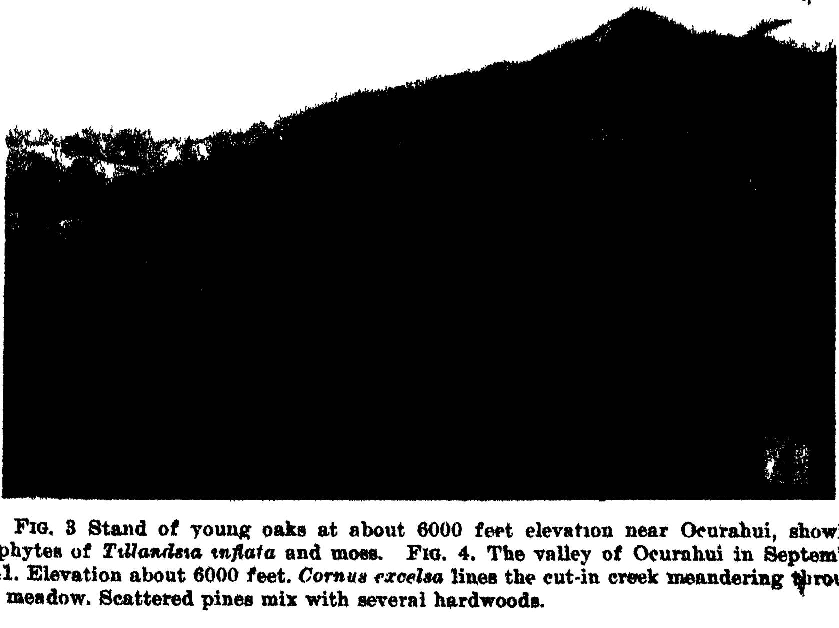

FIG. 3 Stand of young oaks at about 6000 feet elevation near Ocurahui, showing epiphytes of *Tillandsia inflata* and moss. FIG. 4. The valley of Ocurahui in September 1941. Elevation about 6000 feet. *Cornus excelsa* lines the cut-in creek meandering through the meadow. Scattered pines mix with several hardwoods.

deep canyons, following upwards high into the oak zone. The nearly pure oak forest grades into Pine-oak Forest between 4000 and 5000 feet. Madroño, *Arbutus*, is common at 6000 feet and above. The numerous communities and the heterogeneous associations are indicated in the following annotated list of collecting localities.

Varomena, elev. 1000 feet. This village of a few hundred people lies in the foothills at the northwest end of Sierra Surotato and perhaps 70 miles northward from Guamuchil. It is the end of the crude truck road. It is rather typical of the foothill valley country thereabouts. Much of the virgin cover has been cut over and used for milpas or over-grazed. Some of the hill slopes contain small or large areas of but little disturbed woodland of Short-tree Forest composition (2). A messy, aggressive, scrubby cover is commonly adventive upon fallowing milpas and might well bear the name of subtropical scrub of writers, who apparently have not always recognized its real transitory position in the development of the vegetation. An old man in Varomena told me that formerly "encinos" or oaks grew upon the hills above Varomena and that the original "monte" had been cut away. However, some relics of the virgin forest cover remain and one which was visited lay about two miles northeast of the village on a northern slope. It showed a good forest growth with a general stature of mature trees about 30 to 40 feet, dominated by a mixture of drought-deciduous species. The relatively large mesic leaf (average area perhaps 75 cm.^{2}) was more common than the smaller pinnatifid type as represented by the *Mimosaceae* and *Burseraceae*. The former type was generally palmately divided as in some of the common dominants such as *Ceiba acuminata, Cochlospermum vitifolium*, and *Tabebuia palmeri. Ipomoea arborescens* var. *pachylutea* was one of the large-leaved dominants and formed large trees about 40 feet in height with a trunk diameter of two feet or over. It is one of the common tree species through the lower elevations of Sierra Surotato, occurring both in virgin cover and on cut-over areas. Four different species of *Bursera* were found in this segment of forest,, some with finely cut leaflets. A few vines were climbing trees and *Cissus rhombifolia* was collected. Secondary shrubbery was only thinly present and little difficulty was found in getting about through the trees. On the whole its composition is typically Short-tree Forest except for the light infusion of oaks, which may be explained by an original adjacent formation of Savanilla occurring transitorily through the region and previously reported near Sierra Tacuichamona (3).

Savanilla is a minor member of the foothill vegetation. Arborescent species from Thorn Forest, Short-tree Forest, and Oak Forest occupy the rocky outcroppings, where rapid water carriage of weathering products does not allow appreciable soil formation, while turf grasses cover the intervening evener slopes whose soil is a coarse mixture of gravels and clay. The basic rock extrusions are commonly the heights of volcanic pediment which underlies the shallow surface soils. The topography of such terrain is much less precipitous than the Barranca Region proper and the best development of Savanilla is in rolling or slightly broken topography. Those who regard grassland as a late and more highly evolved feature in the development of organic covering are here happily sustained in this striking illustration. The arborescent species are limited to the physiographically younger part of the terrain, the degrading rocks, while grasses monopolize the aggrading miniature plains and gentle slopes. The arborescent mixtures often run strongly to the Cuajiotal type, but not to the degree described in southern Mexico (4), and as observed elsewhere in this formation along the west coast. The trees are preponderantly drought-deciduous and short-statured.

Las Mesas, elev. 3000 feet. Las Mesas, a half day's pack trip southeastward from Varomena, is a rancho with two or three houses in what may be called bench land about half way up Sierra Surotota. Small mesas support a grass cover with oaks and Short-tree Forest species upon adjacent slopes and canyon origins. The mesas themselves are trifling but interesting instances of atypical savanna. Local physiographic features and climate have united to effect unusual mixing of dominant species and with this there is an inherent similarity to the lower lying Savanilla.

Striking associations are the rocky glades and ridges of *Ipomoea–Bursera* stands, the littered rocky slopes of pure oaks on northern slopes, and a highly mixed deciduous forest on southern exposures. The tall slender *Bursera arborea* is found in canyon origins. Herbs and shrubs are plentiful and highly mixed in moist situations with highland and lowland species overlapping.

The soil is shallow, volcanically derived, and the run-off rapid. Pines are lacking. The climate is most equable. The rocky terrain and shallow soils appear to be the chief factors in limiting the vegetational configuration, resulting generally in bringing together a number of plants that can gain foothold within their respective limits in amounts of soil needed. Dwarf thick-stemmed Burseras only 4–6 feet high were found growing out of the crevices of bare rocks, while their normal-statured brothers stood by, 15–20 feet high, in shallow pockets of soil.

Fog is not prevalent at this elevation and is correlated with a relative lack in the epiphytic population. The pendulous lichen is lacking altogether, orchids and *Tillandsia* infrequent.

Varied grass stands occupy most level spaces and gentle gradients. Both turf and bunch grasses are found on open slopes, while *Paspalum plicatum* was found thriving in moist depressions together with *Cyperus* and *Cuphea procumbens.* The natives consider this grass good forage. Along the trail up to Las Mesas beautiful specimens of *Lemaireocereus montanus* were observed.

Ocurahui, elev. 6000 feet. Ocurahui is a scattered settlement of four or five houses about a day and a half by mule eastward from Varomena. It is a delightful, park-like valley cradled in the pine lands on the northern end of Sierra Surotato (fig. 4). A shake-roof storehouse was hospitably donated by Don José Rochas, the loquacious, intelligent, polygamous, and most influential man of that part of the mountain. The storehouse provided the mosos and me adequate shelter from daily summer storms, facilities for drying presses over a smoking fire, and except for the piggy odor emanating from a pen at one end was entirely pleasant. Edible food, however, was scarce and I knew hunger long before my stay was over. The rolling valley was rich in meadow and slope grassland, orchards harbored native herbs, and a dashing creek came out of the surrounding forest, bubbled through the celestial valley, and went out into the woods again, falling over into the deep canyons below. Gentle valley slopes are exceptional in the mountain. It is mostly quite broken and rugged; stout legs and good lungs are needed for getting about.

There are very few pure stands of pine about Ocurahui. The dominant forest type is a mixture of pine and oak, as outlined in the following list, arranged approximately in their order of dominance.

Pinus macrophylla Engel.
Pinus ayacahuite K. Ehrenb.
Pinus oocarpa Schiede.
Pinus lumholtzii Rob. & Fern.
Pinus pseudostrobus Lindl.?

Quercus epileuca Trel.
Quercus pallescens Trel.
Quercus durifolia Trel.
Quercus gentryi Mull.
Quercus candicans Nee.
Quercus endlichiana Trel.
Quercus pennivenia Trel.

Pinus macrocarpa and *P. oocarpa* appear to have the greatest altitudinal ranges. *P. lumholtzii* is common, while *P. pseudostrobus* (?) is scarce, scattered, and not found at lower elevations. On the whole the pine growth is small and only small timber was observed. It is employed for local building, for torches, and for kindling by the natives. Oak is preferred as firewood. *Quercus epileuca* is most abundant upon the moist shady slopes, growing with long straight boles as high as the smaller pines, 15–20 meters. *Q. pallescens* is more common over all types of exposures. *Q. gentryi* is not uncommon and forms rather densely leafy crowns with its narrow leaves. *Q. pennivenia* is restricted to sparse stands on arid slopes with the old trees low and rounding, 6–8 m. high, the branches low and the whole forming a wide symmetrical big-leaved tree. *Arbutus xalapensis* was collected on Sierra Monterrey and often takes its place with the pines and oaks.

In the high moist cool canyons the pines and oaks are often replaced by other more mesophytic trees, nearly all of which are shade-tolerant. Among them are *Styrax argenteus, Ostrya virginiana, Cornus disciflora*, and along the streams *Cornus excelsa, Garrya laurifolia*, and *Magnolia schiedeana*.

The shrub population is rich in species, *Rhus allophylloides* and *Rhamnus* sp. are both shade-tolerant deep-canyon dwellers, the latter forming riparian colonies. *Crotalaria mollicula* is an herbaceous subshrub and it forms extensive colonies upon high moist shade slopes with the low herbaceous *Erythrina montana* infrequently infiltrating. *Triumfetta chihuahuensis* is another canyon shrub, while other members of this tiliaceous genus are common on the more open slopes mostly at lower elevations. Herbs are present in numerous species, occurring only very thinly under pine stands, but occasionally forming a floor covering under mixed forests with such species as *Ipomoea decasperma*. The grass cover is generally quite sparse or lacking under the forest, but thin stands of *Aristida schiedeana* and *Muhlenbergia rigida* occur under the trees.

FIG. 5. Slope forest of oak in the Quebrado de Mansana, September 1941. View over looks tops of *Platanus* trees growing along stream in canyon bottom. *Lysiloma watsoni* in right foreground and a few scattered along gullies with the oaks.

Quebrado de Mansana, elev. 3000–5000 feet. This is a deep canyon between Ocurahui and Las Mesas with an abandoned mine and a few ranchos scattered along the bottom. The north exposures in the upper extents are covered with pines that grade downward into oaks. The southern exposures are dominantly oaks; *Quercus chihuahuensis, Q. tuberculata, Q. albocincta.* The main canyon is lined with tall aliso trees, *Platanus racemosa* var. and with them in the tributary canyons is a strong infusion of barranca and lowland trees; *Ceiba acuminata, Ipomoea arborescens pachylutea, Oreopanax peltatum, Inga eriocarpa,* intermingled with highland species. Shrubbery is rampant under the slope forests and mixed with numerous species; bush-like composite types, wand-like shrubs as *Mimosa* spp. and *Perymenium stenophyllum,* and the small graceful *Triumfetta goldmannii,* and the larger tree-like forms as *Eysenhardtia reticulata, Calliandra gentryi,* and *Heliocarpus* sp. with broad leaves. Altogether they form a closed cover rather difficult to negotiate on the precipitous slopes. On the moist slopes and bottoms the herbs form a thick carpet and are prevailingly shade-tolerant, broad-leaved, turgescent types. Grass species are only scattered here and there in these wooded moist slopes and vary greatly in habit.

The south exposures are essentially more arid and less shrubby. *Eriosema* and coarse grasses are typical of the low well-spaced cover on the more rocky areas, with grasses becoming dense on moist slopes with more soil. The prevailing type of leaf is stiff and harsh in both monocots and dicots, as pointed out as characteristic for the Oak Forest belt of northwestern Mexico (3). Shrub thickets are generally lacking though individual shrubs occur. The herbaceous flora is rich in species, variously adapted to the small moist gulleys or the open arid slopes.

Quebrado de Tarahumare, elev. 2000–5000 feet. The canyon de Tarahumare is the greatest western dissection of Sierra Surotato and contains the most settlements. Its vegetation, therefore, has been more disturbed than that of the Quebrado de Mansana, but in its several precipitous tributaries is still found a great deal of virgin forest. The make-up of the vegetation is essentially similar to that noted for Mansana, but it does contain species rare or lacking in Mansana. It is generally true of Sierra Surotato that every major canyon has its own floristic make-up. As one passes from one canyon to another new plants meet the eye. This is a characteristic of tropical floras, which in North America reach their climax in the exceedingly rich flora of Costa Rica, where within an area of 18,400 sq. miles over 6000 species of plants have been catalogued (5).

The canyons of Sierra Surotato are the meeting places of temperate and tropical genera. The following list shows several plants not previously known as associates or as having over-lapping ranges.

Temperate	Tropical
Ostrya virginiana (Mill.) Koch.	*Distylium* sp.
Platanus racemosa Nutt. var.	*Magnolia schiedeana* Schlecht.
Juglans major (Torr.) Heller	*Brosimum alicastrum* Swartz.
Prunella vulgaris L.	*Garrya laurifolia* Hartw.
Aquilegia aff. *skinneri* Hook.	*Picramnia antidesma* Swartz.?

Agrimonia striata Michx.
Corydalis montana Engelm.
Lathyrus leucanthus Rybd.
Viola neomexicana Greene.
Sisyrinchium arizonicum Rothr.
Cnidosculus angustidens Torr.
Mimulus verbenaceus

Psittacanthus macranthmus Eichl.
Styrax argenteus Presl.
Bocconea arborea Wats.
Chamaedorea sp.
Calathea aff. *cyclophora* Baker.
Maranta arundinacea L.
Klaprothea mentzeloides H.B.K.
Zeugitis latifolia Hemsl.
Cupania glabra Sw.

The records of plants collected on Sierra Surotato not only contribute to our knowledge of the distribution of northwest Mexican plants, but are significant in interpreting the evolution of the floras of southwestern North America. In this mountain is a varied number of plants whose observed or recorded distributions are discontinuous in the latitudes of the desert-tropical transition. A few examples are: *Ostrya virginiana, Agrimonia striata, Lathyrus leucantha, Corydalis montana,* and the disjunct *Platanus racemosa,* all of northern origin. Most of such distributions appear to be relics representing Pleistocene adventives established during glacial epochs, when the cold front was farther south. Examples of plants whose distributions appear to be, or are established as, discontinuous area: *Brosimum alicastrum, Distylium* sp., *Chamaedorea* sp., *Calathea* aff. *cyclophora, Klaprothia mentzeloides, Athyrocarpus leiocarpus, Bocconea arborea, Zeugites latifolia,* and *Cupania glabra.* Such distributions may also be explained on the basis of climatic succession during Pleistocene periods, as relics in the more sheltered canyons left from populations retreating before the south moving cold fronts.

The endemics of the desert-tropical transition, which are many, together with other species of broad tolerances form the great bulk of the flora. They are the great, rugged, plastic element that moved down from the Southwest into Mexico when the arid and the arctic dominated the north temperate (6, 7). Most of the component species, either quickly or slowly, are persistently aggressive in occupying new coastal lands (e.g. the rising coast) and abandoned clearings (2).

The theory of plant migrations under the duress of migrating climatic zones, due to geomorphism and varying sunlight during geologic ages, may be of great value in explaining the development of plant distributions. Certainly no field could be more fruitful in source material than the long desert-tropical transition flanked on the west by the great sea and on the east by the Sierra Madre Cordillera. Here variable temperature operated with altitudinal zonation to give latitudinal movement as well as the more universal longitudinal migration to the mobile biota. Before historical interpretations of distribution can have accuracy, however, an intimate knowledge of plant placements is necessary. On the whole the vegetation of Sierra Surotato and environs is of desert-tropical transition, with a tropical element more preponderant than a temperate one. This is just below 26° north latitude, some 150 miles above the Tropic of Cancer.

In conclusion the following outline approximates the actual zonation of the major forms of vegetation on Sierra Surotato and adjacent coast.

Pine Oak Forest	4500–7000	feet	elev.
Oak Forest—Grassland	2000–4500	"	"
Tropical Montane Forest	3000–4500	"	"
Short-tree Forest	500–3500	"	"
Thorn Forest	0–1000	"	"

These major zones of vegetation are not sharply divided, because of the interpolated and intergrading tropical element. It is represented by both the Short-tree Forest and the Tropical Montane Forest, the latter stratigraphically equivalent to the oak belt, the presence of one or the other conditioned by exposure, soil, and local climate as affected by terrain. The Tropical Montane Forest occupies the equable central elevations where the higher precipitation is retained by good soil and evaporation relatively reduced by the cloud layer. It is limited to the canyons, while the dispersed oak formation is general over the slopes. On the whole this zonation is remarkable and will be analyzed in an early paper.

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GLYCERIA PALLIDA AND G. FERNALDII

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Glyceria Fernaldii (Hitchc.) St. John, based on *G. pallida* var. *Fernaldii* Hitchc., was first proposed as a species by St. John (Rhodora **19**: 75. 1917), and was taken up as a species in the *Manual of Grasses of the United States,* page 94, under the name *G. neogaea* Steud. Mrs. Chase subsequently showed that the type of *G. neogaea* was *G. stricta* (Am. Jour. Bot. **24**: 33–34. 1937).

The characters pointed out by St. John were to a large degree concerned with size of parts; *G. Fernaldii* was described as having a smaller grain then *G. pallida,* shorter anthers, smaller spikelets with fewer florets, more divergent or reflexed branches of the panicle, smaller leaves and lower culms. Table 1 shows how four of these characters appear on 19 sheets in the Herbarium of the University of Wisconsin and the Milwaukee Public Museum. In Wisconsin, at least, there appears to be no very clear-cut line between leaves 2–8 mm. wide (*G. pallida*) and leaves 2–3 mm. wide (*G. Fernaldii*), between anthers 1 mm. long (*G. pallida*) and anthers 0.2–0.5 mm. long (*G. Fernaldii*), between spikelets 4–7-flowered (*G. pallida*) and spikelets 3–5-flowered (*G. Fernaldii*), or between spikelets 6–7 mm. long (*G. pallida*) and spikelets 4–5 mm. long (*G. Fernaldii*). Furthermore, the degree of correlation of wider leaves with larger anthers and spikelets falls far short of

TABLE 1. *Glyceria pallida and var. Fernaldii in Wisconsin*

Locality	Width of widest leaf	Length of anther	Florets per spikelet	Length of spikelet
Merrill, Lincoln Co.	8.5 mm.	0.6 mm.	5–7	5.0–6.0 mm.
Neopit, Shawano Co.	5.0 mm.	0.8 mm.	4–5	4.0–5.0 mm.
Mosinee, Marathon Co.	5.0 mm.	0.8 mm.	4–5	4.0–5.5 mm.
Ashland, Ashland Co.	4.0 mm.	0.6 mm.	5–7	4.5–6.0 mm.
Laona, Forest Co.	3.5 mm.	1.8 mm.	3–4	3.5–5.5 mm.
Rainbow Rapids, Oneida Co.	3.5 mm.	0.2–0.4 mm.	3–4	3.5–4.0 mm.
Mellen, Ashland Co.	3.0 mm.	0.8 mm.	3–4	3.0–5.0 mm.
Ramadke, Clark Co.	3.0 mm.	0.4 mm.	4–6	5.0–5.5 mm.
Madeline Is., Ashland Co.	3.0 mm.	0.4 mm.	3–5	3.0–3.5 mm.
Price Co.	3.0 mm.	0.4 mm.	4–6	4.5–6.0 mm.
Rainbow Rapids, Oneida Co.	3.0 mm.	0.2 mm.	3–4	3.0–3.5 mm.
Moose River Dam, Douglas Co.	2.5 mm.	0.4 mm.	4–6	4.5–5.5 mm.
Ramadka, Clark Co.	2.0 mm.	0.4 mm.	4–6	4.5–5.5 mm.
Mather, Juneau Co.	2.0 mm.	0.4 mm.	3–4	3.5–4.5 mm.
Bruce, Rusk Co.	1.5 mm.	0.4 mm.	3–5	3.5–5.5 mm.
Grand View, Bayfield Co.	1.0 mm.	0.4–0.6 mm.	3–4	4.0–4.5 mm.
Phillips, Price Co.	1.0 mm.	0.4 mm.	3–4	3.5–4.0 mm.
Tomahawk, Lincoln Co.	1.0 mm.	0.4 mm.	3–4	3.0–4.0 mm.
Hayward, Sawyer Co.	1.0 mm.	0.4 mm.	3–5	3.5–5.0 mm.

TABLE 2. *Glyceria pallida and var. Fernaldii outside of Wisconsin*

Locality	Width of widest leaf	Length of anther	Florets per spikelet	Length of spikelet
New Bedford, Massachusetts	10.0 mm.	1.0 mm.	5–6	5.5–6.0 mm.
New Bedford, Massachusetts	8.0 mm.	1.0–1.4 mm.	6–7	6.0–7.0 mm.
New Bedford, Massachusetts	8.0 mm.	1.0 mm.	5–7	5.5–7.0 mm.
Harwich, Massachusetts	7.0 mm.	0.6 mm.	6–7	5.5–6.5 mm.
Noble Co., Indiana	5.5 mm.	1.0 mm.	3–4	3.5–4.5 mm.
Hanover, Massachusetts	5.0 mm.	0.8 mm.	5–6	5.0–6.5 mm.
New Bedford, Massachusetts	4.5 mm.	1.0–1.2 mm.	3–5	4.0–5.0 mm.
Barrington, New Hampshire	4.5 mm.	0.8 mm.	5–6	4.5–5.5 mm.
Durham, New Hampshire	4.5 mm.	0.6 mm.	3–5	4.5–5.0 mm.
Barrington, New Hampshire	4.0 mm.	0.8 mm.	4–5	5.0–5.5 mm.
Newfield, New Jersey	3.5 mm.	1.2 mm.	4–5	5.0–6.0 mm.
Orono, Maine	3.0 mm.	0.6 mm.	4–5	4.5–5.5 mm.
Amherst, Nova Scotia	3.0 mm.	0.4–0.6 mm.	5–6	4.5–5.0 mm.
Hartford, Connecticut	2.5 mm.	0.8–1.0 mm.	3–5	4.5–6.0 mm.
Temple, New Hampshire	2.5 mm.	0.4 mm.	3–5	3.5–5.0 mm.
Belgrade, Maine	2.5 mm.	0.4 mm.	2–5	3.0–5.0 mm.
Southport, Maine	2.0 mm.	0.4 mm.	4–5	3.5–5.0 mm.
St. Louis Co., Minnesota	2.0 mm.	0.4 mm.	3–5	4.0–6.0 mm.
Lake Co., Minnesota	2.0 mm.	0.4 mm.	5–6	4.0–6.0 mm.
Golden Lake, Ontario	2.0 mm.	0.4 mm.	3–4	3.5–4.5 mm.

demonstrating two clearly separable groups. Difference in lengths of anthers appears perhaps most definite among the characters listed by Dr. St. John, but in the plants of Wisconsin its correlation with other characters is not good.

From regions outside of Wisconsin, Dr. St. John undoubtedly had much more material at his disposal than has the present writer, but the characters of the 18 sheets tabulated in table 2 show only slightly better correlation of width of leaves with length of anthers and size of spikelets; they scarcely do more than suggest that var. *Fernaldii* is a smaller phase of *G. pallida*, perhaps recognizable as a northern variety.

HERBARIUM OF THE UNIVERSITY OF WISCONSIN
MADISON, WISCONSIN

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STUDIES IN THE SAPOTACEAE—VI. MISCELLANEOUS NOTES

ARTHUR CRONQUIST

My revisions of several American groups of the *Sapotaceae*, under the auspices of the Chicle Development Company, are now concluded. During the course of that work various notes on other groups in the family have been accumulated. These are here presented, in order to make them available to future students of the family, and to make certain names available for use. An artificial key to the American genera of the family, as I understand them, is followed by notes and comments alphabetically arranged by genera. The citations of herbaria are the same as those used in previous papers of this series.

1. Sepals biseriate, mostly 3 plus 3, occasionally 4 plus 4, rarely 2 plus 2; corolla-lobes (except in a few species with 3 plus 3 sepals) with evident paired dorsal petaloid appendages. ***Manilkara.***
1. Sepals not biseriate, or, if so, then 2 plus 2 (in *Pouteria*); corolla-lobes with lateral appendages (in *Dipholis* and *Bumelia*) or exappendiculate.
  2. Staminodes present.
    3. Stipules present, conspicuous. ***Chromolucuma.***
    3. Stipules wanting.
      4. Corolla thick, fleshy, globose, with valvate lobes. ***Sarcaulus.***
      4. Corolla not especially thick, the lobes imbricate.
        5. Seed-scar small, basilateral.
          6. Corolla-lobes without lateral lobes; endosperm present. ***Mastichodendron.***
          6. Corolla-lobes with lateral lobes, except in a few species of *Bumelia*.
            7. Endosperm present; ovary nearly always glabrous; unarmed. ***Dipholis.***
            7. Endosperm wanting; ovary usually hairy; usually more or less spiny. ***Bumelia.***
        5. Seed-scar long, lateral.
          6. Endosperm present.
            7. Leaves striate, alternate; filaments attached at the corolla-throat. ***Micropholis.***
            7. Leaves not striate.
              8. Leaves conspicuously reticulate, alternate; filaments attached at the base of the corolla-tube. ***Achrouteria.***
              8. Leaves with arcuate-ascending primary lateral veins and numerous fine reticulate-parallel veins perpendicular to the midrib, opposite or subopposite; filaments attached at the corolla-throat. ***Sysygiopsis.***
          6. Endosperm wanting.
            7. Leaves not glaucous; secondary lateral veins ordinarily evident below; staminodes generally well developed and regular. ***Pouteria.***

7. Leaves more or less glaucous beneath, the secondary lateral veins obscure beneath; staminodes irregularly developed. species of *Oxythece.*
2. Staminodes absent.
  3. Endosperm present. *Chrysophyllum.*
  3. Endosperm wanting.
    4. Locules 2–5, each containing one ovule; seed-scar long, lateral.
      5. Distal portion of the filaments abruptly tenuous, reflexed in bud. *Pradosia.*
      5. Distal portion of the filaments similar to the basal portion, not reflexed.
        6. Stipules wanting; leaves usually more or less glaucous beneath, the secondary lateral veins obscure beneath. *Oxythece.*
        6. Stipules usually present, though often deciduous; secondary lateral veins evident and raised beneath; leaves not glaucous, generally large and clustered at the ends of the twigs. *Ecclinusa.*
    4. Locule 1, by failure of the partition; ovules 2; seed-scar relatively small, basilateral. *Diploon.*

Diploön Cronquist, gen. nov.

Tree; leaves alternate, weakly striate; flowers clustered in the axils or at recently defoliated nodes; sepals 5; petals 5, joined only at the base; stamens 5, epipetalous, opposite the corolla-lobes, the filaments basally much-thickened; staminodes none; ovary glabrous, unilocular by failure of the partition; ovules 2, basilaterally attached to a cushion-like basal placenta; fruit fleshy, single-seeded; seed with orbicular not very large basilateral scar; endosperm wanting.

Arbor foliis alternis tenuiter striatis; flores axillares, sepalis 5, petalis 5 ad basim connatis, staminibus 5 epipetalis corollae lobis oppositis, staminodiis nullis, ovario glabro uniloculare per septum defectum, ovulis 2; fructus monospermus semine exalbuminose area derasa moderate parva basilaterali orbiculari.

A single known species:

Diploön cuspidatum (Hoehne) Cronquist, comb. nov.

CHRYSOPHYLLUM CUSPIDATUM Hoehne, Ostenia 302. *pl. 8.* 1933.

An excellent description and plate of this species was provided by Hoehne. Careful examination of a number of flowers, including some kindly sent to me by Dr. Hoehne from the type tree, shows only vestiges of a partition between the ovules. All other American genera of the family, and so far as I am aware all of the old-world genera as well, have as many locules as ovules, and this feature has generally been considered to be a family character of the *Sapotaceae*. *Diploön* does not seem allied to any other family, however, and in my opinion the failure of the partition is not sufficient reason to exclude it from the *Sapotaceae*. Dr. Robert W. Hess, of the Yale University School of Forestry, has kindly examined a specimen for me, and tells me that there is nothing in the wood anatomy to preclude its being a member of *Chrysophyllum*. Aside from the structure of the ovary, *Diploön* differs from all other American *Sapotaceae* in the combination of estaminodial flowers and relatively small basilateral seed-scar. It further differs from *Chrysophyllum* in the absence of endosperm. The glabrous ovary, while unusual in the family, is shared among the American *Sapotaceae* with *Mastichodendron* and *Dipholis*, both of which have staminodes and albuminous seeds. The conspicuously thickened filaments are not to my knowledge matched by any American member of the family, but this character may be of no more than specific importance.

The following specimens of *Diploon cuspidatum* have been examined; most of them are sterile.

Dusén s.n., Tacarahy, Paraná, December 12, 1914 (S); *Dusén 15319*, Serra do Prata, in silva primaeva, Paraná (S); *Hoehne 28358*, Jard. Bot. Sao Paulo (A, F, NY, US, Y); *Glaziou 9501*, entre Queimado et Rio d'Ouro, Rio de Janeiro (S); *Glaziou 9505*, near Rio de Janeiro (K), *19598*, near Rio de Janeiro (NY).

Mr. C. L. Gilly has kindly pointed out to me that the name *Manilkara emarginata* (L.) Britt. & Wils. (1926), which I adopted in my treatment of the North American species of *Manilkara* (Bull. Torrey Club **72**: 550–562. 1945), is a later homonym of *Manilkara emarginata* Lam (1925). The species I had in mind properly becomes *Manilkara jaimiqui* (Wright) Dubard, Ann. Col. Inst. Mars. III. **3**: 16. 1915. The following new combinations are necessary:

MANILKARA JAIMIQUI (Wright) Dubard subsp. **jaimiqui** (Wright) Cronquist, comb. nov. *Mimusops jaimiqui* Wright in Griseb. Cat. Pl. Cub. **64**. 1866.

MANILKARA JAIMIQUI (Wright) Dubard subsp. **emarginata** (L.) Cronquist, comb. nov. *Sloanea emarginata* L. Sp. Pl. 512. 1753.

MANILKARA JAIMIQUI (Wright) Dubard subsp. **wrightiana** (Pierre) Cronquist, comb. nov. *Mimusops wrightiana* Pierre, Symb. Ant. **5**: 171. 1904.

MANILKARA JAIMIQUI (Wright) Dubard subsp. **haitensis** (Cronquist) Cronquist, comb. nov. *Manilkara emarginata* subsp. *haitensis* Cronquist, Bull Torrey Club **72**: 558. 1945.

In my treatment of the North American *Sapotaceae* (Lloydia, in press), I included the single species of *Oxythece* in *Pouteria*, following Eyma's reasoning that the presence of irregularly developed staminodes in some species (including the North American one) invalidated the distinction between the two genera. I now feel that, although the technical character does break down, *Oxythece* is better treated as a distinct genus. It apparently forms a natural, readily recognizable group, not too difficult of definition, and may be nearly as closely related to *Pradosia* as to *Pouteria*.

Oxythece pallida (Gaertn. f.) Cronquist, comb. nov.
Lucuma pallida Gaertn. f. Fruct. **3**: 130. *pl. 204*. 1807.
Oxythece hahnianum Pierre ex Duss. Ann. Inst. Col. Mars. **3**: 387. 1897.
Oxythece fabrilis Pierre, Symb. Ant. **5**: 160. 1904.
Pouteria pallida Baehni, Candollea **9**: 352. 1942.

It is interesting to note that Baehni is so impressed by the importance of the development of staminodes, as opposed to endosperm, as the distinction between *Pouteria* and *Chrysophyllum* (in his greatly extended definition of each) that he dismembers this species and refers the estaminodial extreme (*Oxythece fabrilis*) to "*Chrysophyllum* sp."

Oxythece schomburgkianum (Miq.) Cronquist, comb. nov.
Myrsine schomburgkiana Miq. in Mart. Fl. Bras. 10: 315. 1856.
Chrysophyllum oleaefolium Spruce ex Miq. in Mart. Fl. Bras. 7: 101. 1863.

This species has the leaves merely glabrous rather than glaucous beneath, with the secondary lateral veins a little more evident than is usual for the group, but is otherwise very similar to *Oxythece*, and does not seem to belong anywhere else. Short of reviving the ill-defined monotypic segregate *Elaeoluma* for it, the species must be referred to *Oxythece*.

Oxythece ferreirii Cronquist, sp. nov. Twigs coarse, glabrous; leaves opposite or offset, glabrous, the blade elliptic, blunt, 8–15 cm. long, 4–6.5 cm. wide, the petioles stout, about 1–1.7 cm. long; primary lateral veins arcuate, impressed above, slightly impressed and loosely reticulate beneath; secondary lateral veins obscure above, slightly impressed and loosely reticulate beneath; flowers clustered in the axils, the pedicels glabrous, about 4–5 mm. long; sepals glabrous, rounded, elliptic or ovate, about 3.5–6 mm. long; corolla glabrous, about 4–6 mm. long, the tube very short; staminodes none; filaments straight, attached at the level of the sinuses; anthers about 2 mm. long; ovary closely appressed-hairy, 3-locular; style glabrous, 2 mm. long; fruit unknown.

Arbor, ramulis crassis glabris, foliis glabris ellipticis obtusis 8–15 cm longis 4–6.5 cm. latis, petiolo 1–1.7 cm. longo, venis primariis arcuatis supra impressis infra vix elevatis, venulis supra obscuris infra tenuiter impressis laxe reticulatis; flores axillares pedicellis glabris 4–5 mm. longis, sepalis glabris 3.5–6 mm. longis, corolla glabra 4–6 mm. longa tubo brevissimo, staminodiis nullis, filamentis fauce affixis antheris 2 mm. longis, ovario 3-loculare, stylo glabro 2 mm. longo; fructus ignotus.

TYPE: *Ferreira 516*, Brazil (K).

Additional specimen: PERU: Loreto: *Williams 3669*, Iquitos (F).

This species is obviously related to *O. schomburgkianum*, but differs in its broader leaves, longer petioles, and slightly larger flowers.

Pouteria subsessilifolia Cronquist, sp. nov. Shrub about 3 m. high, with thick scanty latex; young twigs rather coarse, finely and rather loosely hairy; leaves firm, elliptic-oblong, obtuse or rounded at the apex, rounded or subcordate at the base, about 3.5–6.5 cm. long and 16–37 mm. wide, pubescent on both sides with short-stalked two-forked rufous hairs, soon becoming glabrous above, only in age if at all glabrate below, but the hairs eventually fading; primary lateral veins about 10–18 pair, not very prominent; secondary lateral veins obscure; petioles short and stout, about 2–4 mm. long; flowers about 5–15 in axillary clusters which may develop an axis as much as 15 mm. long; pedicels rufous-hairy, about 6–9 mm. long; sepals 5, hairy like the pedicels, about 1.8–3.5 mm. long; corolla about 3.2–

3.8 mm. long, sometimes scarcely exceeding the sepals, the 5 lobes rounded, slightly auriculate, a little longer than the tube; filaments short, attached about at the level of the sinuses; anthers introrse, 1.0–1.3 mm. long; staminodes irregularly developed, about 0.2–0.6 mm. long, or some of them apparently wanting; ovary 2-locular. with laterally attached ovules; style glabrous, about 1.5 mm. long; fruit unknown.

Frutex 3 m. alta, foliis elliptico-oblongis subsessilibus basi rotundatis vel subcordatis, 3.5–6.5 cm. longis 16–37 mm. latis, utrinque molliter pubescentibus supra glabratis, venis primariis ca. 10–18-jugis vix prominentibus, venulis secondariis obscuris; flores axillares 6–9 mm. longe pedicellati, sepalibus 5 rufo-pubescentibus 1.8–3.5 mm. longis, corolla ca. 3.2–3.8 mm. longa 5-lobata lobis tubi paullo superantibus, filamentis brevibus fauce affixis, antheris introrsis, staminodiis irregulariter productis ca. 0.2–0.6 mm. longis, ovario 2-loculare stylo glabro 1.5 mm. longo; fructus ignotus.

TYPE: *Froes 1023*, Andarahy, Serra do Cornelio, basin of River Paraguassu, Bahia, Brazil, October 13, 1942 (A); isotype in herb. B. A. Krukoff.

Local name: Massaranduba.

The affinities of this species are uncertain. Its 5-merous flowers and 2-celled ovary exclude it from any of the sections as defined by Baehni. In his artificial key to the species it becomes lost among several strictly old-world species which are referred by other authors to *Planchonella*. Since several species of *Pouteria* are known to have both 4-merous and 5-merous flowers, and there is a group of species with 4-merous flowers and 2-celled ovaries. its affinities may well lie with these, the section *Discoluma* as defined by Baehni. It is interesting to note that several of the species included by Baehni in this section, which he clearly defines on page 219 of his treatment to include only species with 4-merous flowers, are described by him as having 5 sepals and 5 corolla-lobes. Within this section, the broadly rounded to subcordate bases of the subsessile leaves distinguish *P. subsessilifolia*, and further vegetative and floral difference are seen when it is compared with any one of the species.

Pouteria trilocularis Cronquist, sp. nov. Tree about 25 m. high, buttressed at the base, with thick scanty latex; young twigs closely and obscurely sericeous, soon glabrate; leaves rather narrowly elliptic-obovate or merely elliptic, acuminate to occasionally rounded or obtuse at the apex, narrowed to the base, about 10–28 cm. long and 3–11 cm. wide, glabrous; primary lateral veins about 7–12 pair; secondary lateral veins tending to become perpendicular to the primary ones, toward the margin, but irregular and not much more prominent than the conspicuous and not very fine reticulum; petioles about 1–2.5 cm. long; flowers fairly numerous in axillary clusters or at recently defoliated nodes, the pedicels sericeous, about 4–8 mm. long; sepals 5, sericeous, firm, ovate or deltoid-ovate, acute or acuminate, about 3.4–4.0 mm. long; corolla firm, glabrous, tubular, scarcely exceeding the sepals, about 3.6–4.7 mm. long, the lobes about as long as the tube; filaments short and thick, only about 0.5 mm. long, inflexed, attached at or near the level of the sinuses, often without anthers; anthers about 0.7–1.2 mm. long; staminodes glabrous, inflexed, ovate, acuminate, about 0.8–1.1

mm. long; ovary depressed, almost disciform, closely hairy, obscurely about 6 lobed, 3-locular; style glabrous, nearly 2 mm. long; stigma-lobes 3; young fruits show enlargement of one locule at the expense of the others, with seeds attached along a narrow line for their whole length, indicating that the mature fruit will probably be 1-seeded, and the seed have a long linear scar; mature fruit not seen, but reputedly 3 cm. thick, yellow, and edible.

Arbor 25 m. alta, ramulis juventutis obscure sericeis mox glabratis, foliis glabris ellipticis vel saepius elliptico-obovatis ca. 10–28 cm. longis 3–11 cm. latis, venis primariis 7–12-jugis, petiolis ca. 1–2.5 cm. longis; flores fasciculati pedicellis 4–8 mm. longis, sepalibus sericeis acutis 3.4–4.0 mm. longis, corolla glabra 3.6–4.7 mm. longa, lobis tubo subaequalibus, filamentis crassis 0.5 mm. longis fauce affixis saepe anantheris, antheris 0.7–1.2 mm. longis, staminodiis inflexis acuminatis 0.8–1.1 mm. longis, ovario depresso 3-loculare, stylo glabro vix 2 mm. longo; fructus edulis aureus 3 cm. crassus traditum est.

TYPE: *A. Moysey Adams 2070/w11*, terra firma, Macapa, Baco de Acre, basin of Rio Purus, Acre Territory, Brazil, April 26, 1944 (NY).

Local name: Abiurana.

Three other collections, all in young fruit, are known from Acre Territory, near the mouth of the Rio Macauhan, a tributary of the Rio Vaco, in the basin of the Rio Purus. These are *Krukoff 5283, 5338,* and *5531*. They were distributed as *Sideroxylon bolivianum*, which is a synonym of *Chrysophyllum gonocarpum*.

This species is related to *P. inflexa* (A C. Smith) Baehni, from northwestern Matto Grosso, and *P. obscura* (Huber) Baehni, from 1000 miles away in Para. It agrees with both of these in its 5-merous flowers, corolla-lobes about as long as the tube, filaments attached at the corolla-throat, and trilocular ovary. The three species may be distinguished by the following key:

1. Ovary ovoid or subglobose, its style about 4 mm. long; staminodes erect; filaments about as long as the anthers; leaves rufous-tomentose along the midrib beneath; sepals and young twigs rufous-tomentulose; pedicels about 2–3 mm. long; Para. *P. obscura.*
1. Ovary depressed, its style about 2 mm. long or less; staminodes inflexed; filaments distinctly shorter than the anthers, only about 0.5 mm. long; leaves glabrous; sepals and young twigs merely sericeous; pedicels 4–40 mm. long; Acre Territory and northwestern Matto Grosso.
    2. Corolla glabrous; pedicels about 4–8 mm. long; flowers more than 5 in a cluster; staminodes acuminate; leaves about 10–28 cm. long, on petioles 1–2.5 cm. long. *P. trilocularis.*
    2. Corolla sericeous; pedicels about 25–40 mm. long; flowers about 2–5 in a cluster; staminodes obtuse; leaves about 8–12 cm. long, on petioles 7–12 mm. long. *P. inflexa.*

Pradosia mutisii Cronquist, sp. nov. Similar to *P. glycyphloea*, of southeastern Brazil, in its small (up to 12.5 × 5 cm.), alternate leaves with long (1–3 cm.) slender petioles, and in its small subsessile flowers; differing in the more numerous primary lateral veins of the leaves (about 15–25 pair), in the evident close reticulum of the secondary veins, in the glabrous sepals, and in the short conic style only about 0.5 mm. long; fruit unknown.

A *P. glycyphloeae* differt venis numerosioribus (15–25-jugis), venulis dense et perspicue reticulatis, sepalis glabris, stylo brevi ca. 0.5 mm. longo.

TYPE: *Mutis 4004,* Colombia (US). There are three other sheets at US, bearing the numbers *192, 1020,* and *2324,* but on each of these has been penciled = 4004, and all four sheets look enough alike to have come from the same collection.

Syzygiopsis sericea Cronquist, sp. nov. Tree 10–15 m. tall, with an irregular crown; leaves opposite or slightly offset, elliptic, 5–11.5 cm. long, 2.5–5.5 cm. wide, obtuse or with a short blunt acumen, glabrous and shining above, rufous-sericeous beneath, glabrate or subglabrate in age; primary lateral veins about 6–8 pair, arcuate, strongly ascending, sharply raised beneath; secondary lateral veins numerous, fine, parallel, nearly perpendicular to the midrib, hidden beneath the pubescence; petioles flattened, about 6–10 mm. long; flowers small, the persistent reniform sepals less than 2 mm. long; fruit ellipsoid-globose, bitter, about 2 cm. long; seed solitary, compressed, with a long narrow lateral scar; endosperm present; embryo with thin cotyledons and well-developed caudicle.

Arbor 10–15 m. alta, foliis oppositis vel suboppositis ellipticis 5–11.5 cm. longis 2.5–5.5 cm. latis obtusis vel obtuse breviterque acuminatis supra glabris infra rufo-sericeis in extremis plus minusve glabratis, venis lateralibus primariis arcuato-ascendentibus 6–8-jugis, venulis numerosis tenuissimis reticulato-parallelis ad costam perpendicularibus, petiolis 6–10 mm. longis; flores parvi sepalis vix 2 mm. longis; fructus ellipsoideo-globosus 2 cm longus; semen solitarium area derasa lineari laterali albumine recondito.

TYPE: *Llewelyn Williams 15071,* San Antonio, Rio Orinoco, Venezuela, 121 meters, April 27, 1942 (US).

In the absence of flowers, the generic position of this species cannot be determined with absolute certainty, but the leaf-venation (especially the numerous fine parallel secondary veins extending at right angles to the midrib) is so similar to that of *Syzygiopsis appositifolia* that I am convinced the two are congeneric. *Syzygiopsis* is the only endospermous American genus of the family known to have opposite leaves, but too much stress should not be placed on this feature, since several non-endospermous genera must perforce include both opposite-leaved and alternate-leaved plants.

Syzygiopsis sericea differs from *S. oppositifolia* in its shorter, broader, blunter leaves, that have fewer primary lateral veins and are conspicuously sericeous beneath, the leaves of *S. oppositifolia* being glabrous.

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TORREYA

Proceedings of the Club

Minutes of the Special Meeting of January 8, 1946. The special meeting of the Torrey Botanical Club on Tuesday, January 8, 1946, marking the closing of the Fiftieth Anniversary celebration of the founding of The New York Botanical Garden began with a luncheon at 1:00 p.m. in the Member's Room of the The New York Botanical Garden with 60 people present. After a delightful luncheon and social hour, the scientific program was opened at 2:00 p.m. by President Seaver. Seventy-five people attended this. Dr. Robbins, Director of The New York Botanical Garden, spoke a few words about the history and relationship of the two organizations.

The following addresses were presented:

Professor Lauren C. Petry—"The Place of Botany in General Education."

General education has been defined as "education for an informed responsible life in our society." The teaching of the sciences in the colleges and universities has been more effective in informing students than it has been in increasing their awareness of their responsibilities or their tendency to act in accordance with them. It is proposed to organize the subject-matter of botany courses on the basis of the fundamental concepts and generalizations of the science, and to adopt teaching methods designed to develop in students habits of analysis, criticism, theory formulation, verification, and generalization. It is further proposed that teachers of science at the college level should discuss in detail the practical social, economic, and political problems which science is creating and should indicate the methods to be employed in seeking solutions.

Professor Jacob R. Schramm—"The Object of a Course in Botany for College Students."

Professor Edmund W. Sinnott—"Botany in the Next Half Century."

At a time when we celebrate the close of half a century for an institution like The New York Botanical Garden, it is perhaps worth while to look ahead to the next few decades and try to see the development which botanical science may be expected to undergo in the future.

The great advances in the physical sciences will certainly have their repercussions in botany. New techniques—"tagged" atoms, radiations of many sorts, the electron microscope and others—will make it possible to attack problems which were heretofore insoluble. Among these are the physical and chemical structure of living substance, about which we may expect to learn a great deal in the future. The activities that go on in living systems can also be analyzed far more fully than before. The advances in biochemistry, particularly, will make it possible to follow in more complete detail the various stages in such metabolic reactions as are concerned in respiration and photosynthesis. Growth and development will be an active spot. The general problems of morphogenesis—the controlled development of living things—which is perhaps the central and ultimate problem of biology may be expected to yield at least in part to new methods of attack. Evolution, the problems of which were thought to be largely solved a generation ago, will certainly be actively studied in the future with the techniques of genetics and cytology. Taxonomy is already being revitalised by such research. The problems of the past history of the plant kingdom are by no means solved and much remains to be done here. Indeed, the plant population of the earth is only imperfectly known even today and we may expect much from a fuller exploration of all parts of the world.

Many new practical applications will result from this advanced knowledge in the plant sciences. In agriculture the continued application of knowledge of genetics will undoubtedly produce improved types of plants and better control of disease. The tremendous increase in our chemical knowledge by which so many products heretofore made only by plants can now be synthesized will have its effect upon agriculture. However, even with these advances in chemistry the fundamental syntheses of carbohydrates and amino acids are still made only by plants. It may well be that in the future agricultural crops will be grown primarily for total carbohydrate or protein yield rather than for specific products. The development of tropical agriculture should be important in this connection. The sea produces an enormous amount of plant material, only a tiny fraction of which is now utilized.

Despite the development of atomic power much of the energy needed by our industrial civilization will still come from plant products. As coal and petroleum become scarcer, we shall have to depend on photosynthesis by living plants for this purpose. Techniques are already known by which much of the photosynthetic activity of the globe can be used for the production of fuel.

In medicine the discovery of penicillin shows how important plant syntheses can be for the healing of disease. Many new antibiotics are now being developed from the lower plants and botany is again assuming its ancient role as a source of medicinal materials.

Predicition is rash and many unexpected events may change the future of our science, but the next fifty years will certainly be a time of adventure and excitement for botanists of every sort.

After discussion of these papers, the group was adjourned at 3:45 p.m.

Respectfully submitted,
FRANCES E. WYNNE,
Recording Secretary

Minutes of the Annual Meeting of January 8, 1946. The annual dinner meeting was held on the evening of January 8th at the Men's Faculty Club of Columbia University. There were 94 members and friends present. The business meeting was called to order by the retiring president, Dr. Seaver, at 7:30 p.m. The minutes were approved as read.

Two persons were elected to membership in the club.

The following officers and chairmen of standing committees made reports:

Dr. Simpson, *Corresponding Secretary*
Dr. Wynne, *Recording Secretary*
Dr. Fulling, *Treasurer*
Dr. Rickett, *Editor*
Dr. Clum, *Editor of Torreya*
Dr. Small, *Chairman of the Field Committee*
Dr. Karling, *Historian*
Dr. Dodge, *Delegate to the N. Y. Academy of Sciences.*

Dr. Robbins spoke a few words on the relationship between the New York Botanical Garden and the Torrey Botanical Club and the club's part in founding the Garden.

Dr. Seaver then introduced the guest speaker of the evening, Dr. Joseph Brandt, President of Henry Holt & Co., who gave a very interesting and stimulating paper, "Science Writing and Politics."

Dr. Seaver then announced the election of officers as follows:

President—Dr. P. W. Zimmerman
1st Vice President—Dr. John A. Small
2nd Vice President—Dr. Henry K. Svenson
Corresponding Secretary—Dr. Jennie L. S. Simpson
Recording Secretary—Dr. Frances E. Wynne
Treasurer—Dr. E. H. Fulling

Editor—Dr. Harold W. Rickett
Bibliographer—Mrs. Lazella Schwarten
Business Manager—Dr. Anne Hanson
*Delegate to the Council
of the N. Y. Acad. of Sciences*—Dr. Bernard O. Dodge

Members of the Council

Dr. George S. Avery
Dr. W. H. Camp
Dr. Arthur H. Graves
Dr. George H. Shull

Representative on the Council of A.A.A.S.

Dr. George S. Avery
Dr. Michael Levine

*Representative on the Board of Managers of the
New York Botanical Garden*

Dr. Henry A. Gleason

Dr. Karling moved that the officers elected by vote be approved. The motion was seconded and passed.

The meeting was then turned over to the incoming President, Dr. Zimmerman, who spoke a few words of greeting to the club.

The meeting was adjourned at 8:30 p.m. to permit informal discussion and conversation with friends.

Respectfully submitted,
FRANCES E. WYNNE,
Recording Secretary

Minutes of the Meeting of January 16, 1946. The regular meeting of the Torrey Botanical Club was called to order by President P. W. Zimmerman at The New York Botanical Garden with 35 members and friends present. Minutes of the annual meeting and announcements of new officers were read and approved.

The resignation of Dr. Frances E. Wynne as Recording Secretary was accepted, and Dr. E. E. Naylor nominated and elected as acting Recording Secretary.

President Zimmerman named three members to function as a committee for the Cumulative Index of the *Bulletin* as follows: Dr. Seaver, Chairman, Dr. Rickett, and Dr. Karling.

It was moved and seconded that reprints of the section of the *Bulletin*, formerly *Torreya*, be sent to associate members for a period of one year at a total cost to the club of not more than $100.

President Zimmerman asked for suggestions for a suitable chairman of the Field Committee to replace Dr. Small. Some discussion followed. Mr. R. Platt and Dr. Svenson were suggested, but no action was taken.

The scientific portion of the program consisted of a very interesting and informal talk by Dr. W. H. Camp on "Plant Hunting in Ecuador."

The meeting was adjourned at 4: 30 p.m. for tea and general discussion.

Respectfully submitted,
FRANCES E. WYNNE,
Recording Secretary

Minutes of the Meeting of February 5, 1946. The regular meeting of the Torrey Botanical Club was called to order by President Zimmerman at 8:15 p.m. at Columbia University. Minutes of the meeting of January 16th were approved as read.

President Zimmerman announced that Mr. Ajello of Columbia University had been suggested as a candidate for the office of Recording Secretary for the Club. Mr. Ajello was nominated and elected without discussion.

Two new members, already passed at the Council meeting were elected to associate membership.

The only other business was the appointment by the President of Dr. Cornelia L. Carey and Miss Honor M. Hollinghurst to fill vacancies in the council.

The scientific program of the evening was a paper presented by Dr. George M. Hocking on "The Pharmaceutical Botany of Peppermint." The speaker's abstract follows:

> First, pharmaceutical botany (or medical botany) was defined as paralleling in a general way the various fields of general botany, but the plants studied are of medicinal interest: the chief emphasis being put of course on practical aspects, as far as this is possible. Discussion then followed on the importance of Peppermint, as reflected in its wide usage, cultivation and inclusion in pharmacopoeias. Its nomenclature was briefly discussed, together with what is known of its hybrid origin, discovery and spread from England to the Continent and then to America. Areas of cultivation in this country, mode of propagation and tillage, methods of harvesting and distillation were considered.
>
> The reputedly largest mint farm at Mentha, Michigan, was briefly described. The importance of the volatile oil and its chief component, menthol, were discussed. The uses of the plant were illustrated and its importance technically as well as in foods, medicines and masticatories was indicated. All parts of the plant are used, even the spent herb coming from the still.
>
> Three useful means of identification of the leaf (etc.) by histological methods were detailed: (a) leaf vein islet counts, (b) trichome characteristics, and (c) palisade cell ratios. Of these, the first and second are frequently adequate in fixing identity of a powdered leaf material, whereas the third method is used mainly for confirmation.
>
> The author has carried out determinations for various species of *Mentha* with both leaf vein islet counts and palisade ratios. In this work, he found that the value of vein islet counts for plants growing outside during the summer months showed a high degree of correlation within the species, but that leaves developed in the winter (in greenhouse) showed lower values in plants from identical stocks.
>
> Trichomes of mechanical type are of considerable help in identification of species, as was illustrated, whereas glandular hairs are considered of very little value on account of the similarity of these structures in various species of *Mentha* and indeed throughout most Labiates.

Twenty-six members were present. The meeting adjourned at 9:15 p.m. for tea served by members of the Botany Department of Columbia University.

Respectfully submitted,
E. E. NAYLOR,
Acting Recording Secretary

Minutes of the Meeting of February 20, 1946. The regular meeting of the Torrey Botanical Club was called to order by President Zimmerman at 3:30 p.m. at The New York Botanical Garden. Twenty-five members were present. Minutes of the meeting of February 5th were approved as read.

There was no new or old business to transact and accordingly the meeting was turned over to Dr. Fredda D. Reed, who presented a talk on "Carboniferous Plants and Some Problems of Evolution."

The meeting adjourned at 4:45 p.m. for tea served by members of The New York Botanical Garden.

Respectfully submitted,
LIBERO AJELLO,
Recording Secretary

Minutes of the Meeting of March 5, 1946. The regular meeting of the Torrey Botanical Club was called to order by Dr. Zimmerman at Hunter College at 8:15 p.m. with 150 members and guests present.

The minutes of the meeting of February 20th were approved as read.

The recording secretary read the following motion which was approved unanimously: "That the Club go on record as favoring an arrangement with the Society of American Plant Taxonomists to furnish this Society at cost price reprints of the 'Index to American Botanical Literature' from the *Bulletin* for distribution to the members of the Society in place of the 'Taxonomic Index.' "

Dr. J. S. Karling presented a report on the Biological Institute which is to be organized at the coming St. Louis meetings. This institute will fill the need for a close-knit biological organization which will be able to represent biologists in national and other affairs.

There was no further business, and so the meeting was turned over to Mr. Rutherford Platt who presented a most stimulating lecture on "Art Forms in Nature" illustrated with excellent kodachromes.

The meeting adjourned at 9:20 p.m. and tea was served by the Hunter Faculty.

Respectfully submitted,
Libero Ajello,
Recording Secretary

Minutes of the Meeting of March 20, 1946. The regular meeting of the Torrey Botanical Club was called to order by Dr. Zimmerman at Fordham University at 4:00 p.m. with 57 members and guests present.

The minutes of the March 5th meeting were approved as read.

Dr. Simpson announced that there is to be an additional meeting of the Torrey Botanical Club on the evening of Monday, April 15th, at Columbia University. Dr. J. Van Overbeek will address the Society at that time.

There was no further business and the meeting was turned over to Dr. C. A. Berger who presented a paper on "Naturally Occurring Tetraploidy in the Development of *Allium.*" The speaker's abstract follows:

Polyploid mitotic divisions were found to occur in the large cortex cells of the cotyledon of all young seedlings of *Allium cepa.* They were very abundant in seedlings approximately 15 mm. long, where they were found throughout the cotyledon. In seedlings about 20 mm. long these divisions were concentrated at the base of the cotyledon. In seedlings longer than 20 mm. polyploid divisions were very scarce.

In the long resting stage preceding the division, a double reduplication of the chromosomes takes place. As a result from earliest prophase to metaphase the chromosomes consist of four chromatids held together by a single undivided spindle attachment region (tetra-chromosomes). At metaphase two successive divisions of the spindle attachment region occur. After the first division the tetraploid number of metaphase chromosomes can be counted and the chromosomes are arranged in pairs. The second division of the spindle attachment region results in the separation of chromatids, which then undergo normal anaphase movement. Two tetraploid cells result. These polyploid cells apparently undergo only one mitotic division, since only metaphases with paired chromosomes were found.

This is one of the few cases in which the role of polyploidy in normal development is shown by the direct evidence of polyploid mitotic divisions.

The meeting adjourned at 5:00 p.m.

Tea and coffee were served prior to the meeting by members of the Fordham Faculty.

Respectfully submitted,
Libero Ajello,
Recording Secretary

Minutes of the Meeting of April 2, 1946. The regular evening meeting of the Torrey Botanical Club was called to order by Dr. Zimmerman at Columbia University at 8:30 p.m. with 26 members and guests present.

The minutes of the March 20th meeting were approved as read.

Dr. Zimmerman announced that Dr. J. Van Overbeek is to address the club at a special meeting at Columbia University on April 15th.

The speaker of the evening, Dr. Robbins, was not able to attend and the meeting was turned over to Dr. Karling and Dr. Zimmerman who informally discussed the meetings of the A.A.A.S. held recently in St. Louis.

The meeting adjourned at 9:15 p.m. Tea and cakes were served by members of the Columbia Faculty.

Respectfully submitted,
LIBERO AJELLO,
Recording Secretary

Minutes of the Special Meeting of April 15, 1946. The special meeting of the Torrey Botanical Club was called to order by Dr. J. A. Small at 8:15 p.m. at Columbia University with 34 members and guests present.

The reading of the minutes of the previous meeting was omitted and Dr. Small introduced the speaker of the evening, Dr. J. van Overbeek, head of the Department of Plant Physiology of the Institute of Tropical Agriculture, Mayagüez, Puerto Rico. The speaker's abstract follows. This was prepared by Dr. Marie E. Conklin at the speaker's request.

> Emphasizing that the plant research program at Mayagüez is being directed toward solving problems of both a purely scientific and a practical nature, Dr. van Overbeek proceeded to cite examples from each of these categories of research which is currently in progress at the Institute. Investigation of both chemical and biological aspects of the relation of hormones to the growth, rooting, flowering and fruiting of tropical plants and the application of the results of these investigations to tropical agricultural has been the main objective of this research group.
>
> Fundamental research on the physiological function of leaves in the process of root formation has been conducted on cuttings of *Hibiscus* and other plants. It was found that cuttings, from which leaves had been removed, rarely rooted, even with the addition of indole butyric acid. A combination of indole butyric acid and nitrogenous compounds such as ammonium sulphate or arginine in the presence of sucrose, produced excellent root formation comparable to that of the cuttings with leaves attached and indole butyric acid added. These data clarified the relation of hormones and plant nutrients in the process of root formation. Cuttings of *Cacao* and *Hevea*, which are extremely difficult to root, were made to root by applying the method of submerging in water immediately after cutting to avoid plugging the vascular system with the plant's mucoid exudate.
>
> Pineapples, it was found, could be stimulated to bear flower and fruit, if treated with 0.001% naphthalene acetic acid (or 2–4D), applied to the center of the plant. The exact weight and size of fruit can be predicted, for there is a definite correlation between the number of leaves on the plant at the time of treatment, and the resulting fruit. By using for treatment a variety of pineapple which under natural conditions flowers with difficulty, complete crop control is possible. Thus for a cost of one dollar, over 50 acres of pineapples can be treated, and both the time of harvest and the size of the fruit are controlled. The possibility of hormonal control of flowering in other plants is under investigation.
>
> Use of hormones, or hormone analogs for weed control, particularly in the sugar cane fields, is proving very successful in Puerto Rico. Hand hoeing of sugar cane fields has been the usual procedure, at a cost of about $40.00 per acre. By spraying with 0.05 to 0.1% 2–4D, *Commelina*, *Cyperus*, and other weeds are effectively destroyed without damage to the cane, at a cost of $4.00 or less per acre. Weed eradication in cane fields is very important to insure maximum yield of

sugar by permitting cuttings close to the ground. *Ipomoea* can also be successfully controlled in this way in coffee plantations, where it smothers the trees.

Following his presentation of scientific data, Dr. van Overbeek showed a series of beautiful kodachrome slides from the large collection he has made while in the tropics. They were of unusual interest because they showed the natural beauty of Puerto Rico, while serving to illustrate the experimental work which is being conducted on the native economic crops of sugar cane, pineapple, coffee, vanilla and mango.

The meeting adjourned at 9:15 p.m.

Tea and cakes were served by members of the Columbia faculty.

Respectfully submitted,
LIBERO AJELLO,
Recording Secretary

Minutes of the Meeting of April 17, 1946. The regular afternoon meeting of the Torrey Botanical Club was called to order by Dr. Zimmerman at the American Museum of Natural History at 3:45 p.m. with 9 members and guests present.

The minutes of the April 2nd meeting were approved as read.

Dr. Zimmerman noted that the change in location of the day's meeting was an attempt to improve afternoon attendance by selecting a more centrally located meeting place.

There was no further business and the meeting was turned over to Dr. Svenson who spoke on the "Relation of the Galapagos Flora to That of the South American Main land."

The meeting adjourned at 5:00 p.m.

Respectfully submitted,
LIBERO AJELLO,
Recording Secretary

Minutes of the Meeting of May 1, 1946. The regular evening meeting of the Torrey Botanical Club was called to order by Dr. Zimmerman at Columbia University at 8:00 p.m. with 37 members and guests present.

The minutes of the April 17th meeting were approved as read.

There was no business to transact and the meeting was turned over to Dr. W. J. Robbins, who spoke on some of his recent research on *Phycomyces Blakesleeanus* and some of the Dermatophytes.

The meeting adjourned at 9:30 p.m. Tea and cakes were served by members of the Columbia faculty.

Respectfully submitted,
LIBERO AJELLO,
Recording Secretary

NEWS NOTES

Books and Scientific Periodicals Needed. During the war, the libraries of half the world were destroyed in the fires of battle and in the fires of hate and fanaticism. Where they were spared physical damage, they were impoverished by isolation. There is an urgent need—now—for the printed materials which are basic to the reconstruction of devastated areas and which can help to remove the intellectual blackout of Europe and the Orient.

There is need for a pooling of resources, for coordinated action, in order that the devastated libraries of the world may be restocked as far as possible with needed American publications. The American Book Center for War Devastated Libraries, Inc. has come into being to meet this need. It is collecting and shipping abroad scholarly books and periodicals which will be useful in research and necessary in the physical, economic, social and industrial rehabilitation and reconstruction of Europe and the Far East.

Since shipping facilities are precious and demand that all materials be carefully selected, emphasis is placed upon publications issued during the past decade, upon scholarly books which are important contributions to their fields, upon periodicals (even incomplete volumes) of significance, upon fiction and non-fiction of distinction. All subjects—history, the social sciences, music, fine arts, literature, and especially the sciences and technologies —are wanted.

The following materials are not needed: textbooks, outdated monographs, recreational reading, books for children and young people, light fiction, materials of purely local interest, popular magazines such as *Time*, *Life*, *National Geographic*, etc., popular non-fiction of little enduring significance such as Gunther's *Inside Europe*, Haliburton's *Royal Road to Romance*, etc. Only carefully selected federal and local documents are needed, and donors are requested to write directly to the Center with regard to specific documents.

The Center cannot purchase books and periodicals; it must depend upon gifts from individuals, institutions, and organizations. Each state will be organized to participate in the program through the leadership of a state chairman. Other chairmen will organize interest in the principal subject fields. Cooperation with these leaders or direct individual contributions are welcome. When possible, periodicals should be tied together by volume, and missing issues should be noted on incomplete volumes. All shipments should be sent prepaid, via the cheapest means of transportation, to The American Book Center, c/o The Library of Congress, Washington 25, D. C. Although the Center hopes that donors will assume the costs of transportation of their materials to Washington, when this is not possible reimbursement will be made upon notification by card or letter of the amount due. The Center cannot accept material which is sent collect. Reimbursement cannot be made for packing or other charges beyond actual transportation.

The National Tribute Grove. Recently we received a reprint from the *Congressional Record* of some remarks made by Representative Clarence F. Lea about a year ago concerning this tract of redwood forest which is being preserved in honor of the men and women who have served in the armed forces of the United States in World War II. It is established as a public park by the action of the California State Park Commission with the cooperation of the Save the-Redwoods League, the Garden Club of America, and other organizations. The object is to preserve this grove to symbolize "the eternal gratitude of the Nation eternally expressed." "Citizens throughout the United States are joining with the California park Authorities in assuring the acquisition and preservation of these mighty trees. The forest selected is that of the Mill Creek redwoods, near Cresent City, Calif., and will be a part of the California State park system.

"When completed by private contributions and State funds, the National Tribute Grove will contain more than 5,000 acres of some of the finest redwood forest. Some 1,400 acres, at a cost $260,000, are yet to be acquired under a purchase agreement with the timber owners. Not only will the grove be a symbol of gratitude to all who served in the armed forces, but there will also be opportunity for contributors to record the names of specific members of these forces in The Golden Book, which is to be a permanent volume, enshrined both in Washington, D. C., and in California.

"A national committee of sponsors has been formed, with Hon. Joseph C. Grew, of Washington, D. C., as chairman, and Dr. Robert G. Sproul, president of the University of California, as treasurer."

Mr. Lea goes on to say that the trees of the National Tribute Grove are coast redwoods, *Sequoia sempervirens*, the forests of which are being preserved by a system of State parks and the Muir Woods National Monument near San Francisco, which was a gift to the Nation by the late William Kent. Many of these trees are around 350 feet high and 12 to 17 feet in diameter, measured 5 feet from the ground, and some are known to be more than 2,000 years old. *Sequoia gigantea*, a species of older and more massive trees of the Sierra, has been preserved by the Federal Government in Sequoia, Kings Canyon, and Yosemite National Parks.

"The Naturalists' Directory," edited by **Herman E.** Cassino, contains the names, addresses, and special subjects of study, of professional and amateur naturalists throughout the world. This handy directory has been published regularly for 60 years. The current edition is expected in September.

BOOK REVIEW

Turtox Microscopy Booklet. By A. C. Lonert. 1–43. *f. 1–51.* Chicago: General Biological Supply House. 1946.

Realizing that many people nowadays take the microscope for granted and do not really understand its operation, this booklet was compiled to help "teach the practical application of microscope theory, improve the young microscopist's technique and at the same time increase his range of operations." In seven short chapters, profusely illustrated, the author describes simple experiments, requiring little apparatus, which will give one a better appreciation of the possibilities of his microscope. First he illustrates results which may be obtained with a drop of glycerine as a lens. Then he shows graphically the difference between magnification and resolution, the meaning and importance of numerical aperture as applied to a compound microscope, and the necessity for proper control of the beam of light. Special attention is given to the correction of spherical aberration and to the proper illumination with each type of objective. A chapter on the use of light filters and polarized light brings out some interesting contrasts and shows how the use of these aids may improve the image or reveal new details. Brief discussions of stereoscopic vision with a monobjective binocular microscope, three-dimensional photomicrography, and micro-projection suggest interesting lines to follow for more elaborate uses of the microscope. A number of references are cited for more extended study of the topics discussed. In providing a brief, easily understood introduction to the principles underlying the microscope and its proper use, the author has very admirably accomplished the purpose he set for himself.—HAROLD H. CLUM.

INDEX TO AMERICAN BOTANICAL LITERATURE

PLANT TAXONOMY AND FLORISTICS

(exclusive of fungi)

(See also under Genetics: **Castle; McFadden & Sears; Sherman**; under Ecology: **Ciferri**)

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folded together upward and with their margins rolled inward, and of a terminal growing point (fig. 1). In mid-March, when the most recently expanded leaflets were just maturing, the rudiments of two or three pairs of leaflets might be distinguished in the bud with a hand lens or even the naked eye. The largest rudiment was from 2.5 to 5 mm. long. This bud is naked, in the sense that it is not enveloped in protective scales; but the young organs are covered by a copious growth of short hairs. Similarly, the stem-buds, both terminal and lateral, are unprotected, except for the hairs which envelope the tender rudiments.

In February, when the terminal buds of the branches elongate to produce new leafy shoots, the buds which terminate the rachises also become active, and give rise to new lengths of rachis, bearing additional pairs of leaflets, usually two, but frequently three, and sometimes only one, to each leaf. Until they are practically full grown, these new leaflets are deflexed below the rachis, with their lower sides facing each other. Even for some time after they have attained their full size, they may be distinguished from the older pairs of leaflets of the same leaf by their much lighter, fresher green.

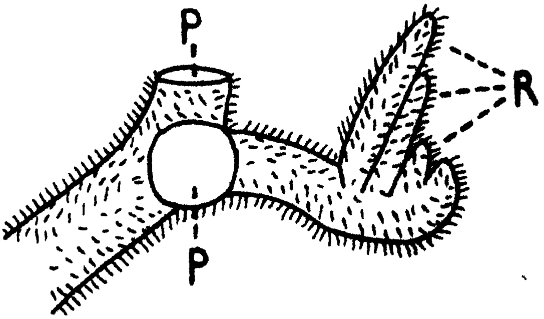

FIG. 1. Apex of rachis of leaf of *Guarea rhopalocarpa*, showing the resting bud. P = bases of petiolules of terminal pair of expanded leaflets, which have been cut away; R = rudiments of three leaflets. × 5.

The growth of the rachis is renewed in this fashion from year to year. Whether it occurs only annually, or sometimes also at shorter intervals, my observations were not continued sufficiently long to determine. The rachis accordingly becomes very long, but always remains slender and withe-like, so that it droops under its own weight and that of the leaflets it supports. The longest rachis which I actually had in hand measured 50 inches (127 cm.), including the petiole, but was only ¼ inch (6 mm.) in diameter near the base. This rachis had produced, as indicated by living leaflets and the scars left by the fallen ones, a total of 22 pairs of leaflets, including two pairs newly expanded during the present season. Allowing for the production of two or three pairs of leaflets each year, its age would have been from 7 to 11 years. Possibly it was even older, for sometimes only a single pair of leaflets is produced at the time of bud-elongation.

The leaflets persist and remain green through several seasons (or at least through several periods of bud-elongation), for in March 5 or 6 pairs of living, mature leaflets were frequently found on a single leaf, while only two or three new pairs are produced at a time. This at least is true of trees in the forest; on trees growing in the clearings, there are usually not so many pairs of living leaflets per leaf, suggesting that they do not survive so long. When the leaflets at length fall away, they leave the basal portion of the rachis quite naked; for, unlike a true branch, it bears no buds in the axils of the leaflets, and hence gives rise to no lateral shoots. In other respects, the rachis quite resembles a slender, whip-like branch, both in external appearance and internal structure; it becomes covered with a corky bark, and produces much secondary wood within. The older, bark-covered portion of the rachis contrasts sharply with the more slender, green terminal part which has newly elongated.

In cross section, the rachis and petiole of *Guarea rhopalocarpa* present many small collateral vascular bundles arranged in an irregular circle or somewhat four-sided figure around the central pith. An active cambium, already forming a nearly complete ring, was found behind the terminal pair of leaflets of a leaf that had a resting bud at its apex. A section through the rachis of a leaf with several increments of growth, made at a point below the oldest living leaflet, revealed a thick layer of secondary wood, composed chiefly of thick-walled fibers, with scattered vessels, uniseriate vascular rays, and an active cambium. Two annual rings could be distinguished. Because a microscope was not available while I dwelt in the region where the *Guarea* grows and no extensive series of material was preserved, it was not possible to correlate the number of annual rings in the wood of the petiole with the number of leaflets that the leaf had produced. This would have made an instructive study.

In an attempt to decide which features, if any, in the internal structure of the axis of the leaf of *Guarea rhopalocarpa* are correlated with its peculiar habit of growth, I examined the leaves of a number of other trees. In many compound leaves, the petiole and lower part of the rachis present in cross-section a structure not unlike that of a young stem, with collateral or at times bicollateral vascular bundles arranged in a ring around the central pith. Often a complete ring of cambium (fascicular and interfascicular) develops early and produces a certain amount of secondary xylem and phloem, the former with typical if short vascular rays. Such stem-like structure, with a closed cylinder of cambium and secondary wood and phloem, was found in petiole or rachis of *Cupania fulvida, Dipterodendron elegans, Jacaranda spp., Simarouba amara, Spathodea campanulata,* *Spondias lutea, Turpinia occidentalis,* etc. Essentially similar structure—including a small amount of secondary thickening—was found in the petioles of such large simple leaves as those of *Cecropia sp., Croton spp., Ricinus communis,* etc. Thus in its primary structure the axis of the leaf of *Guarea rhopalocarpa* is, because of the somewhat irregular arrangement of the vascular bundles, less stem-like than that of some of the other leaves mentioned in this paragraph. In its secondary structure it differs in the greater thickness of wood produced by the cambium, (at least greater in proportion to the whole diameter of the petiole), in the presence of annual rings, and in the formation of cork, which is by no means common on petioles.

There are many woody plants whose lateral shoots behave much like compound leaves. These are chiefly trees and shrubs which produce a multitude of small leaves set close together on branches of determinate growth. At the time of leaf-shedding, these plants, instead of dropping each tiny leaf individually, economize effort and cast off their twiglets with the foliage still attached to them. The bald cypress, the arbor vitae, the araucaria and other conifers belong to this class. The willow sheds first its leaves and then many of the slender twigs which bore them, just as many trees with compound leaves drop first their leaflets and then the naked rachis to which they had been attached. The Central American rubber tree (*Castilla*) also sheds the lateral, leaf-bearing branches from the lower part of its straight trunk, which produces few permanent branches

But although there are so many examples of branches which simulate compound leaves, I am familiar with no other example of a compound leaf which simulates a branch so completely as this. Even the great, twice-compound leaves of *Jacaranda Copaia,* each of which represents, functionally, an entire branch system—for until it is forty or fifty feet high, the slender, pole-like young tree commonly produces no branches unless injured—is of perfectly determinate growth. In due course each leaf, a yard or two in length, falls away in its entirety, leaving the trunk thickly covered with conspicuous scars. One must go to plants of very different kinds to find a parallel with the perennial leaves of *Guarea rhopalocarpa* and related species. *Welwitschia mirabilis* of the deserts of southwestern Africa produces only a single pair of leaves, that must serve this curious gymnosperm during the course of a long life, passed amid the most severe climatic conditions. But these are simple, strap-like leaves, and elongate from the base rather than at the apex. A somewhat closer parallel to the leaves of our *Guarea* is found among ferns of the genus *Dicranopteris.* The scrambling fronds of these tropical ferns branch repeatedly in a dichotomous fashion, and produce resting buds in the angles of the principal forks. After a period of quiescence, the buds become active and increase the length of the frond, very much as the bud at the apex of the rachis of *Guarea* increases the length of the leaf.

SUMMARY

Guarea rhopalocarpa, a medium-sized tree of the Costa Rican mountains, is distinguished by the unusual density of the foliage of its narrow crown.

Each of the pinnately-compound leaves consists, when first expanded, of from one to four pairs of opposite leaflets, and bears at the apex of the rachis a resting bud containing the rudiments of several additional pairs of leaflets. The following year, at the same time that the tree produces new leafy shoots, the bud at the tip of the rachis becomes active and gives rise to an additional length of rachis, bearing from one to three additional pairs of leaflets. Thus the leaf grows in length from year to year, behaving much like a branch, but without lateral buds. The individual leaflets appear to persist for two or possibly three years. The rachis may reach 127 cm. in length and produce a total of 22 pairs of leaflets, including those living and fallen, indicating an age of from seven to eleven years for the whole branch-like leaf.

The petiole and rachis of the leaf of *Guarea rhopalocarpa* present in cross-section a stem-like structure and are early provided with a closed ring of cambium. In this they agree with the axis of many other large compound leaves, also with the petioles of big simple leaves. They differ from the corresponding parts of the other leaves examined in the relatively greater thickness of the secondary tissues resulting from their greater age, the formation of annual rings in the wood, and in the production of a corky bark.

San Isidro del General,
Costa Rica

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THE ORIGIN OF THE MICROSPORANGIUM OF PSEUDOTSUGA[1]

GEORGE S. ALLEN

In view of the important principles involved, it is surprising that Bower's (1896) observations and deductions relative to the sporangium have been so completely neglected by more recent investigators. Bower's discovery that there exists in the ferns a parallel ". . . between the bulk and mode of segmentation of the apices of root, stem, and leaf, and the bulk and segmentation of the sporangia of the same plants" is very significant. Bower came to the conclusion that "the mode of segmentation of sporangia in vascular plants at large corresponds to that of their apical meristems, and the generalization may be extended as follows: *where the apical meristems are disstinctly stratified, the structure of the young sporangium is stratified also; in those plants in which there is a non-stratified structure, with one or more initial cells, and frequent periclinal division of superficial cells near the apex of the stem, leaf, or root, there the structure of the young sporangium is not distinctly stratified.*" Bower summarized his viewpoint in these words: "The study of sporangia or synangia of a plant should be carried out in the light of a knowledge of the segmentation of its apical meristems," and made the significant suggestion that "a renewed enquiry into the detailed development of the pollen-sac of Gymnosperms may be expected to yield facts of interest in view of the recent demonstrations of the non-stratified structure of the meristems at the apex of their axes (Douliot 1890; Koch 1891)."

In view of these pertinent suggestions, it is worth while to enquire into the ontogeny of the microsporangium of *Pseudotsuga* as a representative of the gymnosperms, and to relate it to the structure and behavior of the shoot apex of the same plant. Before this can be done, however, it is necessary to clear up as far as possible the confusion which exists in the literature as to the precise meaning of the term "archesporium."

In 1880, Goebel introduced the term "archesporium" to designate the parent cells of the sporogenous tissue in the vascular plants (see Bower 1908, p. 106). Bower (1908, 1935, etc.), in his many references to the sporangium, has used "archesporium" consistently with its original meaning. Smith (1900) suggested that the term be retained in its original sense for the seed plants, but that it should signify the superficial cell or cells in the pteridophytes from which the spore-forming tissue is derived. This was a somewhat confusing attempt to distinguish between the superficial and "hypodermal" origins of the sporangia in the pteridophytes and seed plants respectively. With this change in its meaning, "archesporium" became practically synonymous with "sporangial initial(s)" and has since been used in this sense by several investigators (Coulter & Land 1905; Nichols 1910; Coulter & Chamberlain 1912; Dupler 1919; Chamberlain 1935; Campbell 1940). Crozier (1892) and Jackson (1916), in their glossaries of botanical terms, give the original meaning of the term as introduced by Goebel. Unfortunately, recent authors (Chamberlain 1935, Campbell 1940), in dealing with the microsporangium of conifers, did not emphasize the fundamental difference which *apparently* exists between the origin of sporangia in all seed plants and that in the lower eusporangiate plants. For example, Chamberlain likened the ontogeny of the conifer microsporangium to that of *Selaginella* or *Lycopodium*; yet he stated that in conifers there is a *hypodermal* cell, or layer of cells, which may be called the archesporium (sporangium initials), whereas in fact the lower vascular plants have *superficial* initials which give rise to the sporangium.

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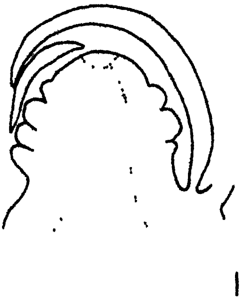
[1] Dr. Adriance S. Foster suggested this problem and the study was made under his direction at the University of California, Berkeley.

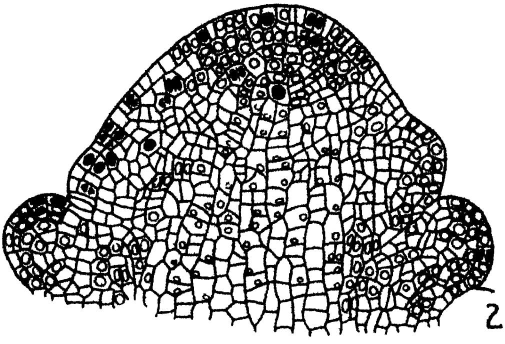
Bower (1908) has pointed out that because the archesporium was recognized successfully in certain cases, there has been a tendency to expect similar success in all cases. To the present writer, the term "archesporium" implies early and precise predestination of certain cells to become sporogenous. In cases where the primary sporogenous cell(s) cannot be recognized, or where there is no single layer from which *all* the sporogenous tissue is derived, the use of archesporium seems ill-advised and misleading (Smith 1900, p. 324). Bower (1908) restricted his use of the term to those cases "... where the cell or cells which give rise to the sporogenous group is obvious ..."

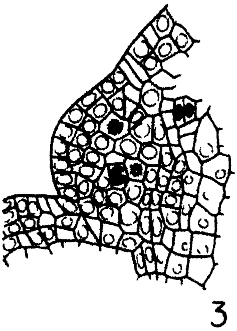
This lengthy discussion has been necessary because of the confusing comparisons which have been made between the sporangia of pteridophytes, gymnosperms, and the angiosperms on the basis of their ultimate origin. In order to avoid misunderstanding, the term "archesporium" will not be used with reference to *Pseudotsuga*; where reference to the literature is necessary, "sporangium initial(s)" will be added in parentheses in cases where "archesporium" refers to a cell or group of cells which give rise to *both* the wall layers and the sporogenous tissue.

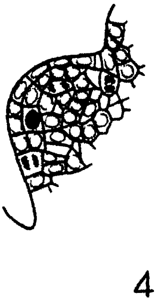
ONTOGENY OF THE MICROSPOROPHYLL

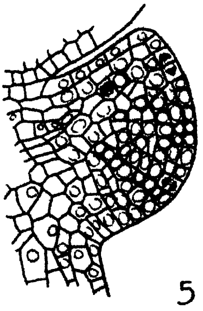
Microsporophylls arise acropetally on the flanks of the strobilus apex (figs. 1, 2) and, in the earliest stages, are very similar to foliage-leaf primordia (figs. 3, 4, 7, 8). They are first evident as a group of surface cells which have elongated radially and then divided periclinally. Continued periclinal and anticlinal divisions of the surface cells and their derivatives produce a symmetrical hemispheric protuberance which for a short time develops by a form of apical growth (fig. 4). The latter ceases rather abruptly when the primordium reaches a length of about 75 μ, at which time it is a symmetrical dome with its main axis at right angles to the surface of the strobilus. At a similar stage of development, a foliage-leaf primordium has already exhibited an upturning due to asymmetrical growth; its abaxial surface cells elongate more rapidly than those of the adaxial surface. Apical growth virtually ceases at this early stage in both kinds of primordia and continued growth in length of the appendages is intercalary.











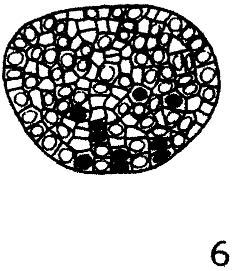


FIG. 1. Diagram of a microsporangiate strobilus in median longisection showing zonal pattern of the apex and the arrangement of the sporophyll primordia. August 12, 1942. ×35. FIG. 2. Longisection through a microsporangiate apex. Note the rapid differentiation within the central tissue zone. August 12, 1942. ×146. FIG. 3. Longisection through a young microsporophyll showing evidence of numerous periclinal divisions in the surface cells. ×250. FIG. 4. Longisection through a slightly larger microsporophyll. ×250. FIG. 5. Longisection of an older microsporophyll showing anticlinal rows of cells in the abaxial region which have resulted from continued periclinal division of surface cells and their derivatives. Note the surface anticline near the apex. ×250. FIG. 6. Transsection of a microsporophyll at a point 25 microns from the surface of the strobilus and 75 microns from the tip of the sporophyll. Note the anticlinal rows of cells in the abaxial region. ×250.

Beyond this early stage, cells of the adaxial surface of the microsporophyll begin to vacuolate and cell division is infrequent (figs. 8, 9); when it does occur the new wall is always anticlinal. Abaxial surface cells continue to divide actively, both periclinally and anticlinally, resulting in a growth in volume of the young sporophyll (figs. 4, 8). The center of meristematic activity gradually shifts from the apex of the sporophyll towards the abaxial surface, the central region of which becomes the generative area of the young sporangia. It is significant that the activity of the abaxial surface cells and their derivatives does not result in a decided upturning of the sporophyll as might be expected; this is due in part to the predominance of periclinal divisions in this region, and in part to the elongation of the cells of the adaxial surface. In contrast, the young foliage-leaf primordium exhibits an early upturning as described. The leaf and the sporophyll primordia are, therefore, distinguishable from one another at an early stage of development.

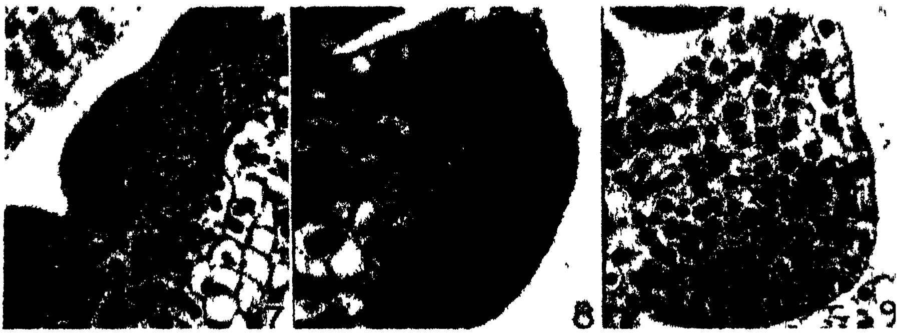


FIG. 7. Longisection through a young microsporophyll. Note the numerous surface periclines. August 12, 1942. × 191. FIG. 8. Longisection through a larger sporophyll showing anticlinal rows of cells in the abaxial region and an anticlinal division near the apex. Note the differentiated appearance of the adaxial surface region and the meristematic condition of the abaxial region. × 342. FIG. 9. Longisection through a still older microsporophyll in which the abaxial surface region is still highly meristematic Note the surface pericline. × 191.

The latter are more massive and shorter and stand nearly perpendicular to the strobilus surface with only a slight upturning of the tip; foliage-leaf primordia show a narrow angle of insertion and the apical portion is more or less appressed to the surface of the shoot apex.

ONTOGENY OF THE MICROSPORANGIUM

An attempt has been made in this study to trace the microsporangium to its ultimate origin as has been done successfully for many of the lower vascular plants (Bower 1908), and for certain of the cycads (Smith 1907, Starr 1910; see Chamberlain 1935). It has not been possible, with the material at hand and the microtechnique employed, to find any good evidence for the existence of a "hypodermal archesporium" (sporangium initials) as described by Chamberlain (1935) for conifers and cycads. Sporogenous cells cannot be recognized with certainty until a relatively late stage of development; the first of these appear deep within the tissue of the young sporangium, often from four to six cells in from the abaxial surface. The continued growth in volume of the sporangia mainly as a result of numerous surface periclinal divisions is significant; there is no "dermatogen" or protoderm covering the young microsporophyll or its sporangia. Therefore, the concept of a "hypodermal" origin for the sporangium of this conifer cannot be entertained.

It has not been possible to trace the origin of the sporangium to the division of any given cell or group of cells for the reason that, from the time of its inception, the microsporophyll exhibits numerous surface periclines which continue until sporogenous cells are differentiated deep within the two sporangia. It is realized that there may be a precise origin as there is in many lower tracheophytes. At the same time, the evidence suggests that a potentially sporogenous mass of cells is built up by the activity of the abaxial meristem and that within this mass only certain cells fulfil their potentialities. It is of interest that a similar lack of precision or predetermination appears to exist at other critical points in the life history of *Pseudotsuga,* particularly in the growing apices of root and shoot, and in the developing embryo (Allen 1945).

The following conclusions appear to be justified on the basis of the observations described.

1. There is no protoderm covering the young sporophyll completely or covering its two young sporangia. A considerable part of the growth in volume of the sporophyll and sporangia is due to continued periclinal divisions of surface cells. The sporangia are not invested by a true sporophyll *epidermis* as is the case in the angiosperms (see Coulter & Chamberlain 1912; Hayward 1938), and *apparently* in other gymnosperms (Chamberlain 1935). The surface cells of the sporangium wall ultimately form the epidermis of the sporangium; this is not the case in the angiosperms or, according to some authorities (Chamberlain 1935, Smith 1900, Campbell 1940), in the seed plants as a whole. The "exothecium" (see Goebel 1935, p. 1792) of *Pseudotsuga* is therefore the outer layer of the sporangium wall; the "endothecium" of angiosperms likewise is the outer wall layer but is covered by the epidermis of the anther in the early stages. On this basis, the microsporangium of *Pseudotsuga* is closely homologous with the sporangia of the lower eusporangiate tracheophytes. Furthermore, there is a close similarity between the non-stratified structure of the vegetative shoot apex (Allen 1945) and the non-stratified structure of the microsporangium, a fact thus supporting the general thesis of Bower (1896). In contrast, in the angiosperms the sporangium is from the beginning invested by a protoderm as is usually the case with the shoot apex (see Bower 1896, p. 8, footnote).

2. It seems probable that the sporogenous tissue has a much less precise origin than is true of many other vascular plants.

3. The microsporangium of *Pseudotsuga* appears to retain, even to exaggerate, the somewhat indefinite and crude ontogeny characteristic of certain of the lower tracheophytes (see Bower 1908). Its origin is very dissimilar to the precise condition typical of angiosperms, or to the extremely specialized and refined development characteristic of leptosporangiate ferns (Bower 1889).

DISCUSSION

Goebel (1881) concluded, on the basis of a broad comparative study of the sporangia of vascular plants, that the microsporangia of conifers are comparable throughout their development with the sporangia of lower eusporangiate plants. In *Pinus* the "archespore" consists of one hypodermal cell; the "epidermal" cell which lies adjacent to it divides *periclinally* to form the first "tapetal" cell. This implies that the sporangium initial must have been a surface cell which divided to form the archespore and the epidermal cell, the latter then dividing periclinally to produce a primary tapetal cell. This does not agree with the hypodermal origin of the sporangium as described by Chamberlain (1935), Coker (1903), Nichols (1910), Coulter and Land (1905), and others.

Goebel described the change in form of the microsporophyll of *Pinus* during its early development and showed that, whereas the archesporium originally lies near the adaxial side, the sporogenous tissue soon occupies a position near the abaxial surface owing to the asymmetrical growth of the sporophyll. A similar change takes place in the sporophyll of *Pseudotsuga* as described above, but it was not possible to recognize an archesporium and follow its change in relative position; the shift of the center of meristematic activity has been described.

Coker (1903) reported a hypodermal origin for the microsporangium of *Taxodium*. Nichols (1910) stated that the archesporium (sporangium initials) in *Juniperus* is first recognizable as a plate of radially elongated cells, from four to six in number in a single longitudinal section; these divide by periclinal walls and the archesporium continues to grow without any differentiation becoming apparent. Finally, the outer layer divides periclinally to form the tapetum internally and the inner layer of the sporangium wall; the latter is covered by an epidermis which finally becomes the monolayered wall of the mature sporangium. Nichols contrasted this condition with that seen in the angiosperms where the epidermis is unimportant in the formation of the wall of the mature pollen sac, and implied that the "epidermis" is in both cases homologous.

Coulter and Land (1905) described the microsporangium of *Torreya taxifolia* as originating from a single hypodermal initial, but their conclusions were based upon the behavior of the sporangia which abort to form resin ducts, and not upon normal sporangia. A radial row of four cells is shown in their figure 9 in which the innermost cell is interpreted by the authors as a primary sporogenous cell, the next two as young wall cells, and the surface cell is presumably "epidermal" in nature. Without more exact data than these it is equally logical to propose a surface initial for the sporangium. The authors' interpretation as a microsporangium of the structure figured is open to question in any case.

Dupler (1919) stated that each microsporangium of *Taxus* originates as a single archesporium (sporangium initial) normally in the hypodermal layer. From a very early stage there is an epidermis over the sporophyll and the sporangium wall is invested with a sporophyll epidermis as in the angiosperms. Although Dupler described the epidermis as a distinct layer throughout, dividing only anticlinally, he found "occasional periclines" in the surface layer which gave rise to an epidermis two cells thick at some points. This is suggestive of the behavior observed in *Pseudotsuga,* in which surface periclines are common throughout early ontogeny of the sporangium.

The current viewpoint is apparently summed up by Chamberlain (1935) in the following words: "The development of the microsporangium (of conifers) and its microspores is the usual development of a eusporangiate sporangium, and in the earlier stages, does not differ much from that of *Selaginella,* or even from that of a eusporangiate homosporous form like *Lycopodium.* There is a hypodermal cell, or layer of cells, which may be called the archesporium (sporangium initials). A periclinal division in the archesporium gives rise to two cells, the outer forming the parietal or wall layers, and the inner giving rise to the sporogenous tissue." Campbell (1940) has this to say about the conifer microsporangium: "The development of the pollen sac may be compared with the sporangium of the eusporangiate fern type. In the very early stages there is a hypodermal cell layer, the archesporium (sporangium initials), which divides into an outer layer, contributing to the anther wall, and an inner one which gives rise to the sporogenous tissue. The wall of the pollen sac consists of several cell layers, the innermost contributing to the tapetum, while the outermost layer may persist as the endothecium and with the epidermis forms the wall of the ripe pollen sac." There is a serious lack of agreement between these generalized accounts and the facts observed in *Pseudotsuga.* It does not seem likely that this one conifer differs radically from other conifers studied, and an investigation of forms such as *Abies, Tsuga,* and *Larix* among the Abietaceae, as well as a re-examination of *Pinus, Ginkgo,* and the cycads, is much to be desired.

Investigations dealing with the cycads and with *Ginkgo* (Smith 1907, Lang 1897, Starr 1910, Chamberlain 1935) indicated that the microsporangium of these gymnosperms has a hypodermal origin. Some of the illustrations purporting to support this view are, however, suggestive of the behavior found in and described above for *Pseudotsuga* (see Smith 1907, figs. 11, 28; Starr 1910, fig. 5); surface periclines are indicated and a hypodermal origin seems questionable without other more convincing evidence. It is noteworthy that Wilson Smith (1900), in his discussion of the homology of the archesporium, stated that there may be periclinal divisions in the superficial cells of the sporangium of gymnosperms, but that these occur only *after* the differentiation of the archesporium. On the contrary, all evidence from this study points to a continuity of surface periclines from the visible beginning of the microsporophyll until the differentiation of sporogenous tissue.

From a speculative viewpoint, there are two reasons why a hypodermal origin for the microsporangium of gymnosperms might be considered remarkable. In the first place, the cycads, with their many similarities to the lower vascular plants, might be expected *a priori* to have, in the "conservative" microsporangium, an ontogeny similar to that of the lower eusporangiate tracheophytes. Jeffrey (1917), for example, considered the mature sporangia of cycads closely similar to those of the pteridophytes. It does seem surprising, in view of the many dissimilarities between the cycads and the angiosperms, that the cycad microsporangium should have a precise internal origin much like that in the angiosperms. If such a similarity does exist then Bower's (1896) generalization for the vascular plants does not hold for the gymnosperms. Secondly, the general lack of a discrete surface layer or layers at the shoot apex of most gymnosperms (see Foster 1941) contrasts remarkably with the discrete protoderm which supposedly covers the young sporophyll and its sporangia during early ontogeny (see Smith 1900). It is again emphasized that the shoot apex of many gymnosperms is unstratified whereas the young sporangium is *apparently* stratified; obviously, if this is true, Bower's generalization is in serious error.

Pertinent to this discussion is the statement made by Bower (1908) that in the sporangium of the Ophioglossales, ". . . with the larger size goes less definite segmentation while greater definiteness is seen with the smaller types." On page 112 Bower stated that the sporogenous group ". . . in many of the Eusporangiate forms does not arise from any single archesporial cell, or definite group of cells; moreover, cells which are obviously sister-cells may not unfrequently be found to develop the one sterile, the other fertile. This suggsts on the basis of structure that the fertile tract is a residuum left by advancing sterilization, while the ragged and ill-defined limits point to the conclusion that the sterile and fertile tracts are closely related; in fact, that they had a common origin, and that the final condition represents the balance struck between sterile and fertile development." Further, Bower (1908, p. 319) found in *Isoetes* ". . . the first periclinal divisions . . . do not absolutely define the future sporogenous tissue; it has been repeatedly seen that additions to it may be made by *subsequent periclinal divisions of* *the superficial cells. . . .*" Bower found a similar behavior in *Selaginella* (p. 316–317), in *Equisetum* (p. 377–378), and in *Lycopodium* (p. 314) in a number of cases studied. In view of the observations described above for *Pseudotsuga,* the implications of Bower's findings and deductions are obvious; definite conclusions, however, must await further study of other gymnosperms.

With the exception of *Ginkgo* (Jeffrey 1917, p. 218), gymnosperms are said to have an "exothecium" like that of the pteridophytes, whereas the angiosperms have an "endothecium," that is, the hypodermal layer of the microsporangium is concerned with dehiscence (Goebel 1933, p. 1792). Jeffrey (1917) described the sporangium of pteridophytes and cycads as "ecktokinetic" (equivalent to having an exothecium), and that of the higher seed plants, including *Ginkgo,* as "endokinetic" (equivalent to having an endothecium). The dehiscence layer of angiosperms and of pteridophytes is admittedly the actual outer layer of the sporangium wall, as it is in *Pseudotsuga;* the dehiscence layer is therefore superficial in *Pseudotsuga* and in the pteridophytes, but originates beneath a discrete surface layer in the angiosperms. According to the literature (Chamberlain 1935; etc.), the gymnosperms as a whole could not fit into this picture since the "epidermis" and not the outer layer of the sporangium wall forms the dehiscence layer or exothecium (see Campbell 1940, p. 492). The obvious disagreement between this viewpoint and the behavior described for *Pseudotsuga* suggests that other gymnosperms may have microsporangia which are strictly superficial in nature as they are in *Pseudotsuga* rather than internal as they are in the angiosperms.

In conclusion, it seems significant that the abaxial meristem which produces the microsporangia of *Pseudotsuga* has features in common with the apical meristem of the vegetative shoot (Allen 1945). In particular, neither has a "stratified" structure, which agrees with Bower's generalization for the vascular plants at large. In his noted work on the primitive land plants, Bower (1935) concluded " . . . that on the one hand apical segmentation, and on the other morphological definition whether external or internal are distinct processes, each of which is determined by the apical region as a whole and not by its segments." This concept may indeed be applicable to meristems other than that of the shoot apex and may serve as a trustworthy guide in a study of the meristem which gives rise to the sporangium.

SUMMARY

The microsporangium of *Pseudotsuga* is a superficial structure and the generally accepted concept of a *hypodermal* origin for the sporangium in gymnosperms is open to question. The sporangium cannot be traced to a single cell or group of cells. It has an ontogeny similar to that of the lower tracheophytes, and, unlike the angiosperm microsporangium, is at no time

invested by a protoderm or epidermis genetically continuous with that of the shoot. Bower's concept that a relationship exists between stratification of the shoot apex and stratification of the young sporangium is borne out by this study.

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A SPECIES OF HARPOSPORIUM INVADING ITS NEMATODE HOST FROM THE STOMA

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In 1874 Lohde (3) briefly described a hyphomycete that he found growing parasitically on numerous eelworms belonging to a species of *Anguillula.* To this hyphomycete he applied the binomial *Harposporium Anguillulae;* the generic term then presented for the first time having reference to the crescentically curved, sickle-shaped conidia which the fungus produced terminally on delicate sterigmata arising singly from peculiar round protuberances formed laterally on the hyphal branches or hyphal prolongations that were extended from the multicellular mycelial filaments, from 2 to 4 in number, passing through the animal's body. As the report of Lohde's findings gives only few intimate particulars and lacks all mention of measurements, it would seem to serve far better in establishing the genus than in defining a species. Descriptive details were very adequately provided by Zopf (4) 14 years later in a well illustrated account of a nematode parasite he held identical with Lohde's. The globose sporiferous cells, which in conformity with usage prevailing at the time (1, p. 65; 5, p. 314) he designated as basidia, were stated by Zopf to vary in diameter from 2.5 to 3.6 μ; the sterigmata were represented as mostly being shorter than the diameter of the globose parts; the crescentic conidia were set forth as being 1–2 μ thick and as measuring 7–13 μ along the chord connecting the two ends. From correspondence with these structures and with the chlamydospores which Zopf found developing in the assimilative hyphae within the animal, it is clear that this later author dealt with the same fungus that in my cultures has been more abundantly destructive to nematodes than any other hyphomycete attacking these animals parasitically rather than in a predaceous manner. Occasionally I have encountered *Harposporium* material which, though bearing crescentic conidia, and in general conforming to Lohde's account, appears alien to the ubiquitous species so accurately made known by Zopf. Thus, in a maizemeal-agar plate culture that had been planted with deciduous leaf mold collected on Polish Mountain about 10 miles east of Cumberland, Maryland, early in July, 1935, numerous nematode larvae were found undergoing destruction by a minute *Harposporium* whose globose sporiferous cells measured only 2.3–2.6 μ in diameter, while its sickle-shaped conidia,

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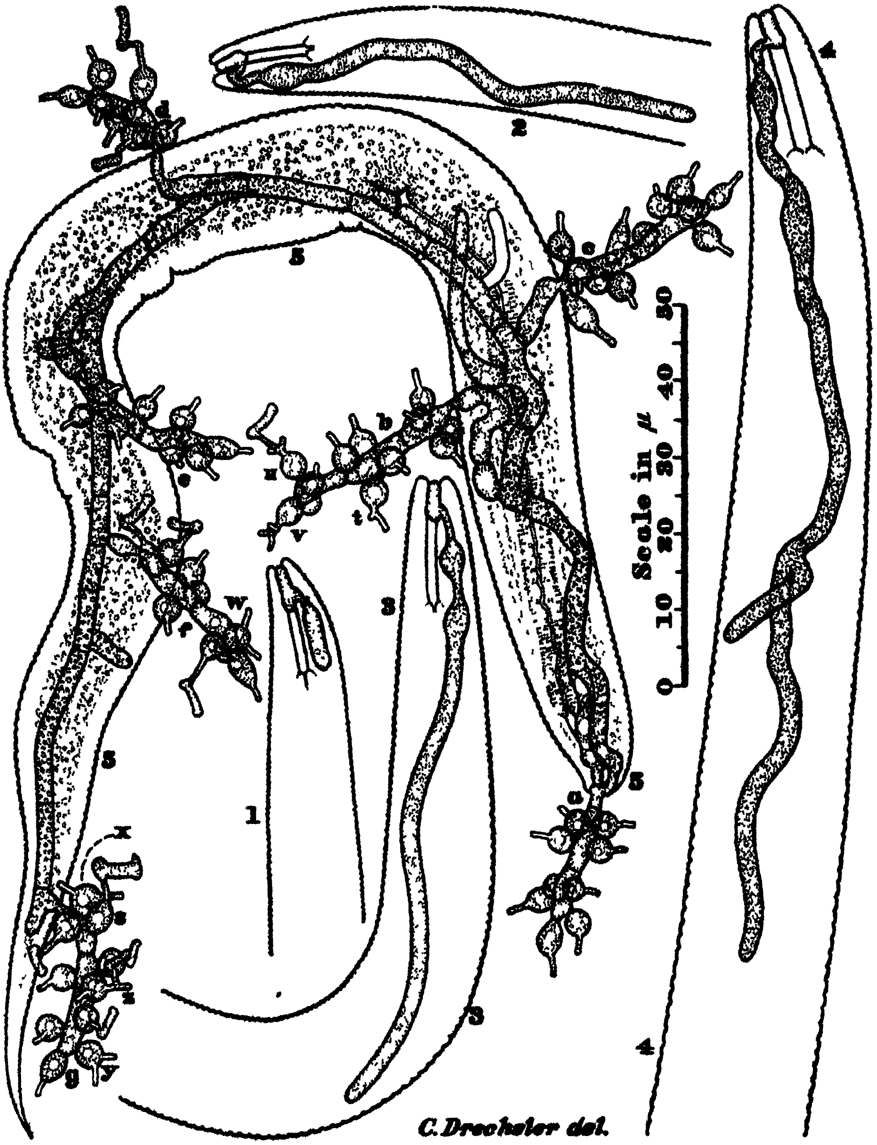

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FIGS. 1–5. *Harposporium bysmatosporum*, drawn to a uniform magnification with the aid of a camera lucida; × 1000. FIG. 1. Conidium of fungus shown lodged in stoma of living animal host (*Rhabditis* sp.); the spore has pushed a narrow germ tube through the stomatal lining and given rise within the fleshy body wall to a young assimilative hypha. FIGS. 2, 3. Longer assimilative hyphae, both still in unseptate unbranched condition; each shown arising laterally from a conidium lodged in anterior portion of the stoma of the living animal host. FIG. 4. A still longer assimilative hypha shown arising laterally from a conidium lodged in the stoma of the living nematode host; this hypha has laid down 3 crosswalls, and is putting forth a branch. FIG. 5. Dead body of animal host with a long borne on single sterigmata about 1.3 μ long and 0.6 μ wide, measured only about 0.8 μ in width and 3–4.5 μ along the chord between the pointed ends. To determine whether this form and certain other forms with crescentic conidia belong to *H. Anguillulae* Lohde *emend.* Zopf, or whether they represent species distinct from it, will require further accessions of relevant material. Much less difficulty is offered by various forms which give rise to conidia not typically crescentic, yet which in their parasitism on eelworms, in their sporulating habit, and more especially in the globose shape of their sporiferous lateral cells (phialides) reveal unmistakably a congeneric relationship to *H. Anguillulae.* In an earlier paper (2, p. 793–800) I have described three such forms as separate species under the binominals *H. helicoides, H. oxycoracum,* and *H. diceraeum.* To these may now be added a fourth species which likewise produces conidia of a very distinctive shape other than crescentic.

The species in question came to light in a maizemeal-agar plate culture which after being permeated with mycelium of *Pythium arrhenomanes* Drechsl. had been further planted with several pinches of partly decayed, friable barley (*Hordeum vulgare* L.) straw collected near Greeley, Colorado, early in October, 1945. As the fungus was not observed until 47 days after the addition of the decaying straw its earlier development must have taken place more slowly than that of most hyphomycetes subsisting parasitically on eelworms. Its attack was confined evidently to sharp-tailed eelworms which were held referable by Dr. G. Steiner to a single species of *Rhabditis.* However, as the manner of infection displayed by the fungus appears about equally well adapted for other species of *Rhabditis*, the likelihood of a wider host range is not to be dismissed.

Infection is found accomplished always by the germination of a single conidium lodged in the anterior portion of the animal's tubular stoma; the spore having very probably reached this place of lodgement through the sucking action whereby the members of the genus *Rhabditis* ingest their food. The individual nematodes that have become gagged by intake of a spore seem usually to abandon their leisurely manner of locomotion and instead will hurry on at their greatest speed; their energetic deportment then recalling the violent locomotion more usually observed in nematodes of the genus *Wilsonema.* Close observation of gagged animals is, of course, impossible while their hurried movement continues. Microscopical examination was carried out conveniently on preparations made by transferring a sizable

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assimilative filament extending lengthwise through it; the filament bears 11 branches, of which 7 have given rise externally to the conidiophorous prolongations u-g; s, phialide bearing a simple sterigma with an unusually large conidium; t, phialide bearing a sterigma with one branch; u, v, phialides bearing single sterigmata with two branches; w-y, phialides, each bearing two separate sterigmata; z, phialide with 2 sterigmata, one of them simple, the other bearing a single branch.

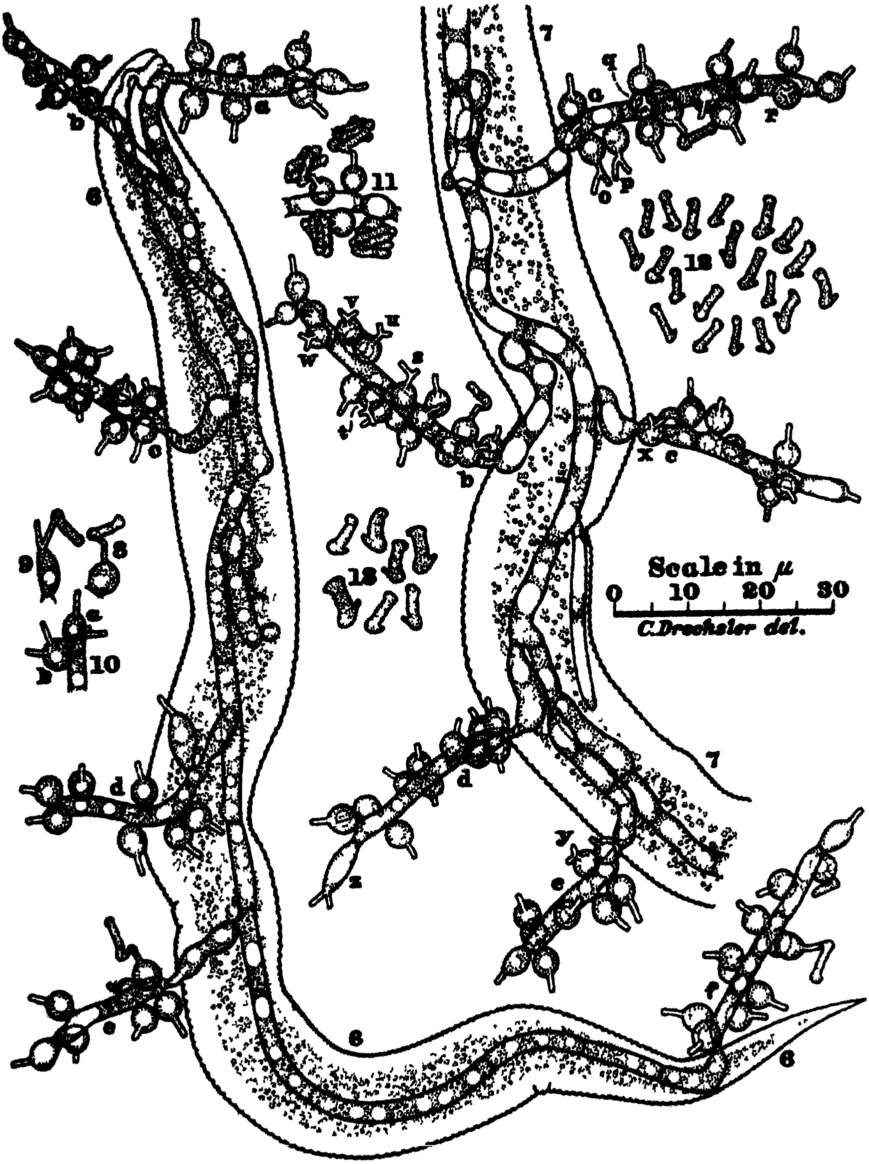
slab of agar from the Petri plate culture to a glass slide and covering it with a cover-glass; the movement of eelworms in such preparations being gradually halted, apparently from suffocation, everywhere except near the periphery of the mount. Among nematodes thus brought to quiescence, gagged specimens are readily detected by noticeable distension of the anterior portion of the stoma, and by the presence of a partition separating the expanded stomatal region from the unmodified posterior region (figs. 1–4). The curious partition represents obviously the spore membrane at the more deeply inserted end of the conidium. As a rule the membrane at the opposite end of the conidium invites less attention, since it usually lies approximately in alignment with the frontal profile of the animal's head and therefore often merges more or less with the outline of the stomatal orifice. The lateral portion of the conidial membrane is generally found so snugly appressed to the lining of the stoma that it no longer can be distinguished as a separate wall, though its presence is betrayed through pronounced thickening in the contour bounding the distended portion of stoma.

Once the conidium is seated securely in the stoma of the nematode it puts forth a single germ-tube from a position near its more deeply inserted end. This germ-tube, mostly about 1 μ wide, penetrates the stomatal lining to enter the fleshy tissues of the head. Sometimes it widens out almost immediately to a diameter in excess of 2 μ (fig. 1), but rather more often such widening is delayed until a length of about 5 μ has been attained (figs. 2–4). The crooked course frequently taken by the young infective germ-tube, as also the visible accumulation of yellow material around it, gives the impression that at the beginning invasion meets with resistance from the affected tissues. Occasionally after widening out the invading hypha may elongate narrowly for some little distance a second time (fig. 3). Whatever impediment may cause this initial inconstancy of width soon becomes inoperative, and thereupon the hypha elongates at a diameter of about 2.5 μ to make its way lengthwise through the fleshy body into the tapering tail until it stops growth perhaps within 25 or 30 μ from the pointed caudal tip (figs. 5, 6) In most of the smaller eelworm hosts, certainly in most eelworms measuring less than 250 μ in length, only a single main assimilative filament is produced; the total absorptive system being, however, augmented substantially through the development frequently of more than a dozen lateral branches at intervals varying from 5 to 100 μ. While the branches do not usually attain lengths in excess of 25 μ within the animal, most of them participate in further development by narrowly perforating the host integument to extend a conidiophorous prolongation outside. With the continued expropriation of host materials required to sustain development of reproductive apparatus externally, the assimilative hyphal system emerges into view more and more clearly. It is then revealed as mostly varying in width between 2.5 and 3.5 μ, and as being divided by cross-walls into segments 5 to 25 µ in length (figs. 5–7). As the fleshy host contents approach exhaustion—the firm muscular oesophages and oesphageal bulb remain recognizable longest, but after a time melt away like the softer tissues—the mycelial segments become pronouncedly vacuolate (figs. 6, 7). When at last the host contents have vanished entirely, the assimilative elements undergo complete evacuation in continuing to supply the reproductive apparatus.

The conidiophorous hyphae (figs. 5, a–g; 6, a–f; 7, a–e) of the fungus closely resemble those of the ubiquitous *Harposporium Anguillulae.* They are mostly extended procumbently if the animal host happens to die on the surface of the agar culture. If, on the other hand, the animal dies well under the surface of the agar, they develop readily in submerged positions. They mostly vary in length from 15 to 40 µ, and in width from 2 to 3 µ; the shorter examples often containing only 2 axial segments (fig. 6, b), while the longer ones frequently contain 5 such segments (figs. 6, f; 7, a) and sometimes a greater number. All axial segments except the terminal one are of generally cylindrical shape, and each of them is beset laterally with globose cells in numbers varying commonly from 2 to 6. Most usually the spherical cell bears a single delicate sterigma together with which it makes up a phialide having the shape of a narrow-necked Florence flask (fig. 5, s; fig. 8). The terminal segment of the conidiophorous hypha serves directly as a phialide, being provided most frequently with a single apical sterigma. As the terminal phialide often has a somewhat prolate venter it approaches in outward shape the more familiar gradually tapering phialides that among hyphomycetes parasitic on nematodes occur in members of the genera *Acrostalagmus*, *Cephalosporium*, and *Spicaria* (2).

Although the larger number of phialides bear individually only a single unbranched sterigma, this single sterigma in more than a few instances gives off a branch and thus comes to be provided with 2 sporiferous tips (figs. 5, t; 7, o–y). Occasionally the sterigma gives off 2 branches, thereby acquiring 3 sporiferous tips (fig. 5, u, v). Sometimes 2 sterigmata arise from the same venter, either close together (figs. 7, z; 9) or from well separated positions (figs. 5, x, y; 10, a); and more rarely 3 sterigmata are borne separately (fig. 10, b). Three sporiferous tips are found present also in scattered instances where 2 separate sterigmata have been produced, one remaining simple while the other has given off a branch (fig. 5, z).

It seems probable that phialides with plural sterigmatic tips may bear a larger number of conidia than those provided with only one tip. In undisturbed condition, strongly vacuolated phialides with single unbranched sterigmata are commonly found bearing individually a cluster of from 4 to 6 conidia in more or less parallel arrangement (fig. 11). The conidia are of bizarre shape in some degree reminiscent of the conidia of *Harposporium*



FIGS. 6–13. *Harposporium bysmatosporum*, drawn to a uniform magnification with the aid of a camera lucida; × 1000. FIG. 6. Dead body of nematode host (*Rhabditis* sp.) with a long assimilative hypha extending lengthwise through it; 6 of the 7 lateral hyphal branches present have given rise externally to the conidiophorous prolongations a-f, which bear phialides furnished uniformly with single unbranched sterigmata. FIG. 7. Median portion of dead animal host, showing 6 branches coming from the main assimilative hypha; five of the branches have given rise externally to the conidiophorous prolongations a-e; o-y, phialides furnished with single sterigmata, each of which bears one branch; z, elongate terminal phialide with two sterigmata arising from its apex. FIG. 8. Globose

diceracum. A narrow, recurved, minute basal pedicel is directed at an acute angle to the main cylindrical portion of the spore. Proximally the spore bulges out rather markedly toward the side opposite the pedicel. At the distal end it often widens perceptibly, the contour here usually bulging slightly less toward the pedicel side than toward the opposite side. On the whole the conidia appear to be somewhat larger than those of *H. diceraeum,* their length varying mostly from 4.5 to 6.5 μ, and their width, measured in the unmodified median region, varying from 0.8 to 1.4 μ (fig. 12). Here and there relatively massive conidia are found measuring 1.5 to 2.1 μ in median width (figs. 5, s; 13).

It may be presumed that the curious modifications in the form of conidia represent features adapting them for lodgment in the stoma of the host animal. Such lodgment obviously affords a much more secure foothold on the eelworm than could ordinarily be provided through adhesion to the integument, being wholly unaffected by any brushing action brought about by the movement of the nematode through materials of harsh texture. Among congeneric forms *Harposporium diceracum* would seem most likely to be similarly adapted for stomatal infection, as its conidia are of size and shape whereby they might fit snugly in the stoma of its usual nematode host, *Plectus parvus* Bastian. The possibility of stomatal infection in *H. diceracum* is hardly to be considered disproved by the single instance of infection from an externally adhering conidium which I happened to observe and which I took occasion to illustrate (2, p. 798, fig. 7, A). In any case the curious adaptational features developed by the Colorado fungus in relation to its manner of attack may be appropriately signalized in a specific epithet compounded in part of a term meaning "plug."

Harposporium bysmatosporum Drechsler, sp. nov. Mycelium nutritum incoloratum, septatum, intra vermiculos nematoideos viventes evolutum, saepe ex unica hypha filiformi 150–300 μ longa (quandoque in pluribus hyphis ejusmodi) et pluribus (vulgo 5–15) ramis constans; hypha et ramis in cellulis 5–25 μ longis 2.5–3.5 μ crassis consistentibus. Hyphae fertiles post mortem animalis extra corpus evolutae; submersae vel repentes, plerumque simplices, rarius parum ramosae, septatae, in axe ex 2–6 cellulis constantes, saepius 15–40 μ longae, 2–3 μ crassae, hic illic ramulos conidiferos (phialas) globosos 3–4 μ crassos ferentes; his ramulis conidiferis saepius unico sterigmate quandoque 2–3 sterigmatibus praeditis; sterigmatibus plerumque sim-

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phialide with a single unbranched sterigma to which is attached a full-grown conidium. FIG. 9. Terminal phialide with two simple sterigmata arising from its apex. FIG. 10. Terminal portion of a conidiophorous hypha, showing a terminal phialide, a, with 2 sterigmata, and a lateral phialide, b, with 3 separate sterigmata. FIG. 11. Median portion of a conidiophorous hypha, showing 4 lateral phialides which have produced clusters of conidia; the number of spores in a group varying from 4 to 6. FIG. 12. Random assortment of conidia, showing usual variations in size and shape. FIG. 13. Conidia of more than usual size.

plicibus, 2–4 μ longis, circa 0.8 μ crassis, subinde 1 vel 2 ramusculis instructis, vulgo 4–6 conidia apice deinceps gignentibus; conidiis continuis, incoloratis, ad formam ossi lacerti (umero) paulum similibus, deorsum in minutum pedicellum oblique recurvis, sursum rotundatis et saepius plus minusve dilatatis, plerumque 4.5–6.5 μ longis, 0.8–2.1 μ crassis, quandocunque ab vermiculo nematoideo singulatim sumptis stoma animalis obturantibus et inde hypham germinationis in corpus ejus intrudentibus.

Vermiculos nematodeos specie Rhabditis necans habitat in stramento (foliis acere caulibusque) Hordei vulgaris putrescenti prope Greeley, Colorado.

Assimilative mycelium colorless, septate, growing within living nematodes, frequently consisting of a single main filamentous hypha 150 to 300 μ long (sometimes of several such hyphae) together with lateral branches numbering commonly from 5 to 15 and measuring from 5 to 25 μ in length; the hyphae and branches being composed of segments mostly 5 to 25 μ long and 2.5 to 3.5 μ wide. Conidiophorous hyphae, after death of animal host, formed in the surrounding or on the underlying material, with respect to their main axis mostly simple, more rarely somewhat meagerly branched, divided mostly by 1 to 5 cross-walls, measuring usually 15 to 40 μ in length and 2 to 3 μ in width, bearing laterally here and there globose conidiiferous cells (phialides) mostly 3 to 4 μ in diameter; these cells commonly provided with a single sterigma, though occasionally provided with 2 or 3 separate sterigmata; the sterigmata usually simple and usually measuring 2 to 4 μ in length and 0.8 μ in width, but occasionally bearing 1 or 2 branches. Conidia commonly formed in clusters of 4 to 6, continuous, colorless, somewhat resembling the human upper-arm-bone in shape, at the base recurved obliquely into a minute pedicel, at the distal end rounded and often noticeably widened, usually measuring 4.5 to 6.5 μ in length and .8 to 2.1 μ in median width, wherever sucked in by a host nematode stopping up the animal's stoma, and then intruding a germ tube into its fleshy body.

Destroying nematodes referable to *Rhabditis* sp., it occurs in decaying straw (stems, leaves, and chaff) of *Hordeum vulgare* near Greeley, Colorado

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ANOMALOSICYOS, A NEW GENUS IN CUCURBITACEAE[1]

HOWARD SCOTT GENTRY

In the determination of recent Sinaloan collections a small cucurbitaceous vine appeared to be generically anomalous. Although clearly related to *Sicyos* it possesses characters atypical of the genus as known in North America. The latest monograph of *Sicyos* is that of Cogniaux published in 1881 (DC. Monog. Phanerog. **3**: 869–899). His later work on the Cucurbitaceae (Pflanzenr. IV, 275. 1916–1924) did not reach the tribe Sicyoidae. In the former work his section of *Sicyos*, *Atractocarpos*, characterized by "Flores feminei solitarii rarius geminati. Fructus compressus, saepius fusiformis, pericarpio tenui," would include the Sinaloa plant under consideration. Section *Atractocarpos* includes six South American species, which, except those with flattened fruits, appear to show no common difference from the Sinaloa plant, which has a nearly terete fruit. All of these species form a distinct and clearly related assemblage characterized by reduced anthers and slender, fusiform, solitary or geminate, long-pedunculate fruits. Because the name *Atractocarpus* is preoccupied by a grass genus and is likewise identical in etymology with *Atractocarpos*, it is not available for what is clearly a genus worthy of separation from *Sicyos*.

Anomalosicyos Gentry, gen. nov. Herbae annuae, scandentes, glabrae vel pubescenti-scabriusculae; folia membranacea, angulata vel lobata; cirrhi 2–3-fidi; flores monoici, parvi vel minuti; masculi racemosi; calycis tubus late campanulatus, dentibus 5 parvis remotis subulatis vel vestigialibus; corolla rotata vel subcampanulata, 5-partita, segmentis triangulari-ovatis, cum calyce omnino confluentibus; stamina 2 vel 3, fundo calycis inserta; filamentis in columnam brevem connatis; antherae ad apicem columnae sessiles in capitulum connatae, loculis arcuatis; flores feminei in eadem axilla cum inflorescentia mascula solitarii vel geminati, pedunculati; corolla tubiforma rotata; staminodia nulla; ovarium lineari-fusiforme, rostratum setosum, uniloculare; stylus brevis, gracilis, stigmatibus 3 papillosis; ovulum unicum, ex apice loculi pendulum; fructus parvis, indehiscens, lineari-fusiformis, teretis vel compressus, longe pedunculatus, pendulus; semen loculo conforme, testa membranacea. Species typicus, *Anomalosicyos barbatus*.

Anomalosicyos barbatus Gentry, sp. nov. Herba scandens; caulis ramique graciles, striati, sparse glandulosi-puberulentes, ad nodos pilis longis albis praediti; petiolus 2–4 cm. longus albi-pubescens, piliolis interdum glanduliferis; folia membranacea, lata cordata, 5–8 cm. longa, 7–10 cm. lata, apiculata subtiliter denticulata, ad basim late emarginata, 3–5-lobata lobis late triangularis, omnibuis lobis aristatis, sparse scabri-puberulenta;

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[1] Publ. No. 839 from the Department of Botany, University of Michigan.

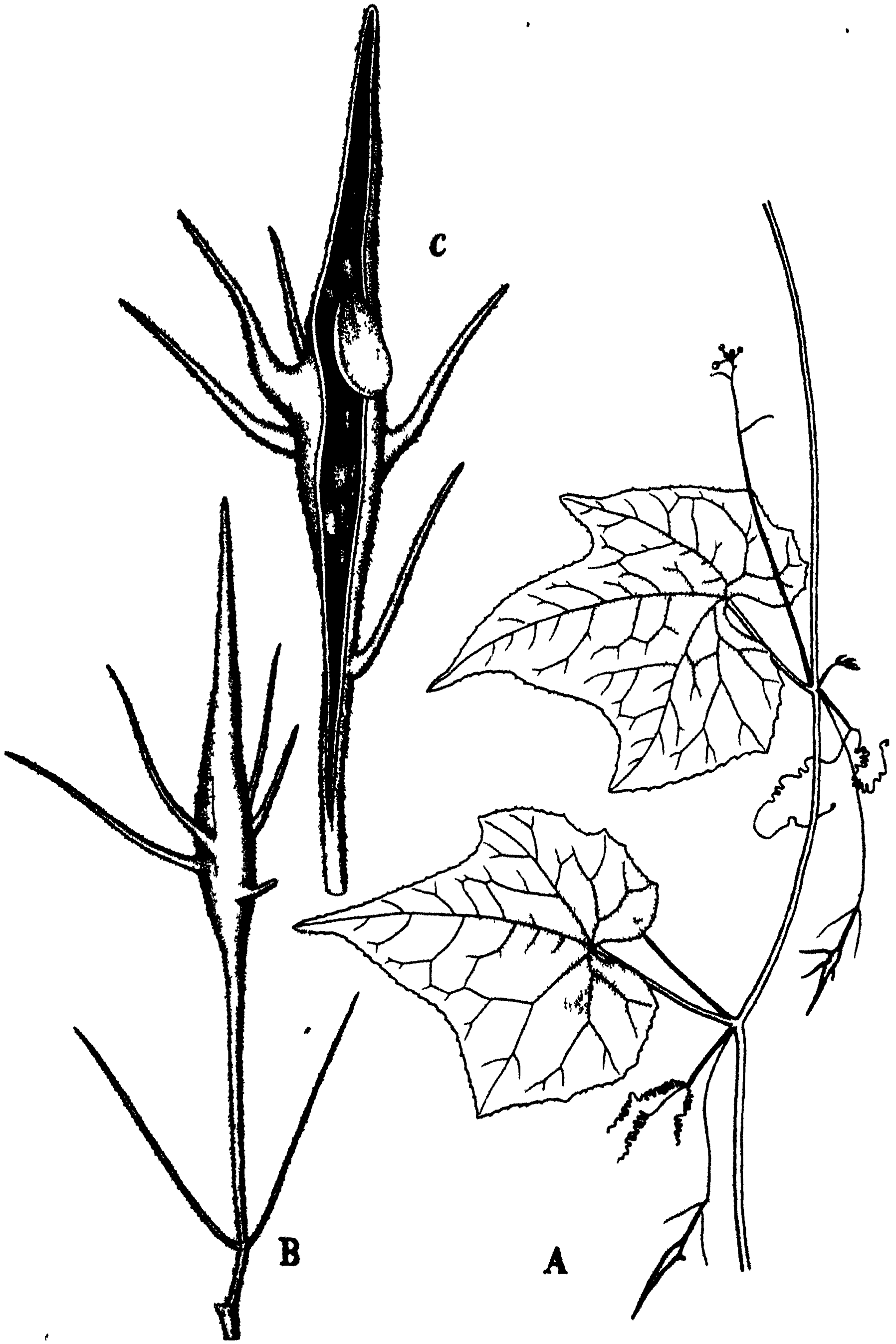

FIG. 1. *Anomalosicyos barbatus*; A, habit, × 0.5. B, fruit, × 4.0, C, fruit opened to show ovule, × 2.4.

cirrhi graciles 3-fidi; ♂ pedunculi filiformes, 6–7 cm. longi, ad apicem leviter puberulentes; pedicelli glabri 7–10 mm. longi; ♂ flores minuti, albi, campanulati; corolla 3 mm. alta, 4 mm. lata, intus glandulosi-hirtella, segmentis ovati-triangularibus, 1.5 mm. longis, leviter hirtellis; sepala vestigialia; antherae 2 vel 3, exsertae, loculis flexuosis arcuatis; ♀ pedunculi filiformes, ad basim sparse glandulosi-pubescentes, fructifer 3–5 cm. longus; ♀ corolla 2 mm. alta, 3 mm. lata, segmentis ovati-triangularibus, 1 mm. longis, intus glandulosi-punctatis; sepala minuta, viridia; pedicelli fructiferi 5–10 mm. longi, aculeis basalibus 5–12 mm. longis, barbartis; fructus 2–3 cm. longus, 2–3 mm. diam., fusiformis; pericarpium tenuissimum, barbatum, aculie ca. 3–6, acicularis, 5–12 mm. longis.

TYPUS: *Gentry 6600,* "Las Mesas, Sierra Surotato, Sinaloa, Mexico, Sept. 15, 1941," in herb. Univ. Mich. Dupla in herb. Stanford Univ., Inst. Biol. Mex., N. Y. Bot. Gard., Harvard Univ., Mo. Bot. Gard., Gentry, Univ. Ariz.

The fruits examined are nearly mature and are apparently indehiscent since the hypanthium, ovary, and ovule tissues are fused with the seed coat and a line of abscission is clearly apparent at the base of stalk joining the peduncle. Such a structure, together with the barbules of both the pericarp and the spinoid prickles, indicates that it is adapted to carriage and dissemination by animals.

In habit this plant greatly resembles the many small species of herbaceous cucurbit vines so numerous through the moist habitats of the tropics and subtropics. Unlike many of these, however, its appearance is singular because of the curiously shaped, gracefully hanging and delicately formed fruits. In *Sicyos* the fruits are flattened-ovoid, densely prickly, and borne in rather dense capitate clusters or corymbs, so that the two genera can readily be separated at sight. *Anomalosicyos* might more easily be confused with *Echinocystis* or *Echinopepon* on superficial examination, since these latter have echinate, dryish, hanging fruits, but they are larger and more densely prickled, to mention the most obvious differences. On the whole, the Cucurbitaceae require microscopic floral examination for generic segregation, since distinct genera may have the same habit and might be carelessly placed in a single species.

Anomalosicyos barbatus forma **lobatus** Gentry, forma nov. Folia profunde 5-lobata, lobis ovati-lanceolata, aristatis. TYPUS: Gentry 6600-A, "Las Mesas, Sierra Surotato, Sinaloa, Mexico, Sept. 15, 1941," in herb. Univ. Mich. Dupla in herb. Gentry, Univ. Ariz., Mo. Bot. Gard., Harvard Univ., N. Y. Bot. Gard.

This form differs from the typical form of the species only in the deeply lobed leaves and was collected in the same small canyon not 50 feet distant from the former. The fruits and the flowers show no taxonomically significant differences. The difference in leaf appears attributable to a segregating Mendelian factor. Many species in other genera of the cucurbits are known

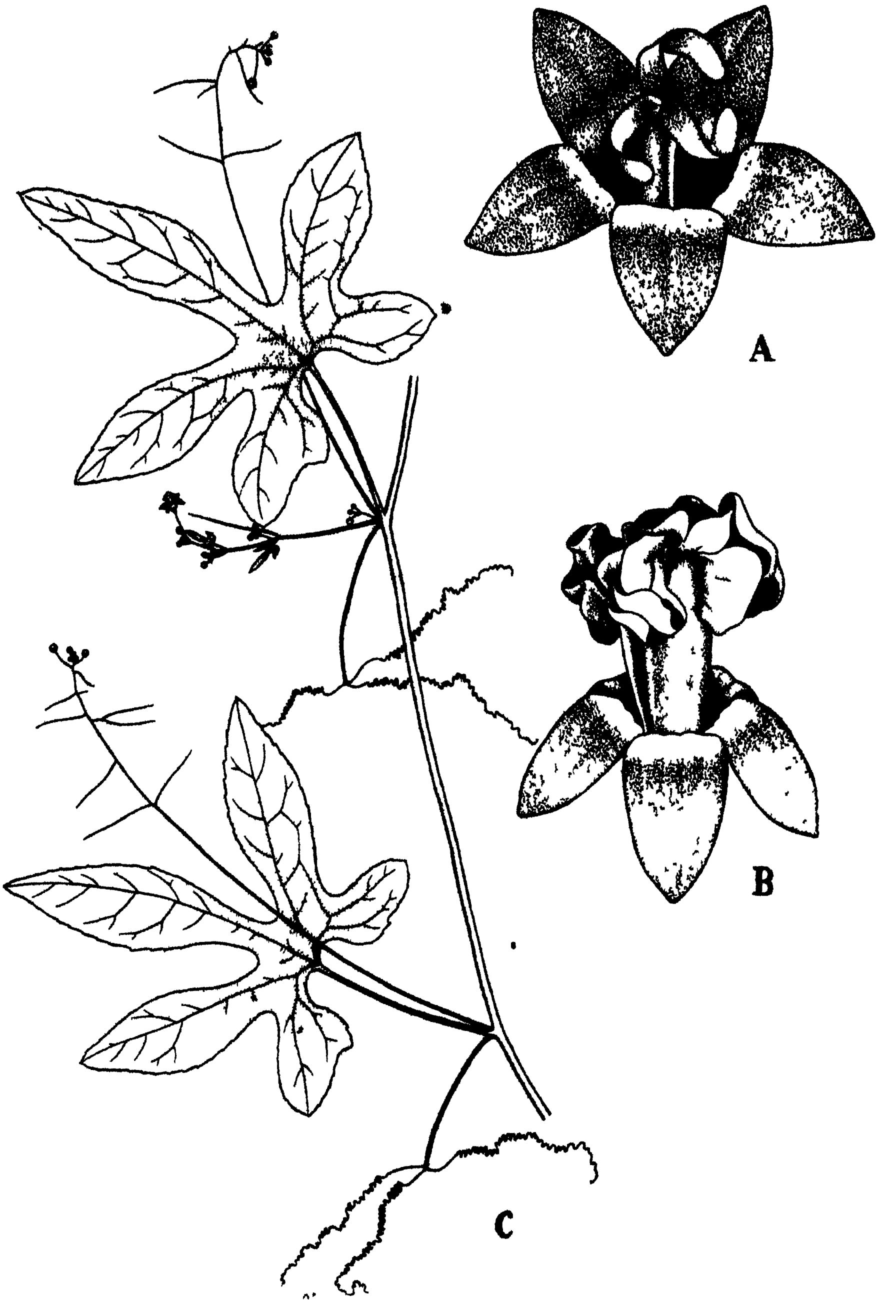

FIG. 2. A, B, *Anomalosicyos barbatus;* female corolla and male corolla with dehisced anther cells, respectively, × 15. C, *Anomalosicyos barbatus* forma *lobatus;* habit showing deeply lobed leaves; × 0.5.

to vary considerably in the form and especially in the dissection of their leaves. Cogniaux rather consistently detailed them as varieties, in accordance with the practice of his times.

The allied South American species are as follows:

Anomalosicyos fusiformis Gentry, comb. nov. *Sicyos fusiformis* Cogn. in Mart. Fl. Bras. fasc. **78**: 108. *pl. 34*. Described from collection taken near Rio de Janeiro, Brasil.

Anomalosicyos Martii Gentry, comb. nov. *Sicyos Martii* Cogn. in Mart. Fl. Bras. fasc. **78**: 109. Brazil; Prov. Minas Geraes and Rio de Janeiro.

Anomalosicyos palmatilobus Gentry, comb. nov. *Sicyos palmatilobus* Cogn. in DC. Prodr. Phanerog. **3**: 891. 1881. "Ad fluvium Daule prope Guayaquil."

Anomalosicyos quinquelobatus Gentry, comb. nov. *Sicyos quinquelobatus* Cogn. in Mart. Fl. Bras., fasc. **78**: 109. "In sylvis Brasiliae prope Bananal prov. S. Paulo."

Anomalosicyos macrocarpus Gentry, comb. nov. *Sicyos macrocarpus* Cogn. in DC. Prodr. Phanerog. **3**: 893. 1881. Mont. Chimborazo (Ecuador?); Venezuela; "prope coloniam Tovar."

Anomalosicyos Andreanus Gentry, comb. nov. *Sicyos Andreanus* Cogn. Bul. Acad. Belg. II. **49**: 200. Ecuador; Mont. Chimborazo, 359 m. elev. (André 3996).

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NOMENCLATURAL NOTES AND A NEW SPECIES OF CUSCUTA

T. G. YUNCKER

Cuscuta colombiana Yuncker, spec. nov. Caules tenuissimi, marcescentes et ad postremum evanescentes ex inflorescentiis. Flores plus minusve carnosi, circa 1.5 mm. longi ab floris basi ad corollae sinus, pediculis plerumque longioribus quam floribus. Inflorescentia paniculato-cymosa formansque fasciculos. Calycis lobi ovato-lanceolati usque oblongi, acuminati, plus minusve se diffundentes. Corollae campanulati, papillati ad basim, lobi ovato-lanceolati, acuminati. Stamina paene tam longi quam corollae lobi. Squamae usque ad stamina, oblongae aut spatulatae, fimbriatae. Styli tenues, longiores quam ovarium globosum. Capsula depresso-globosa, ad postremum circumscissilis.

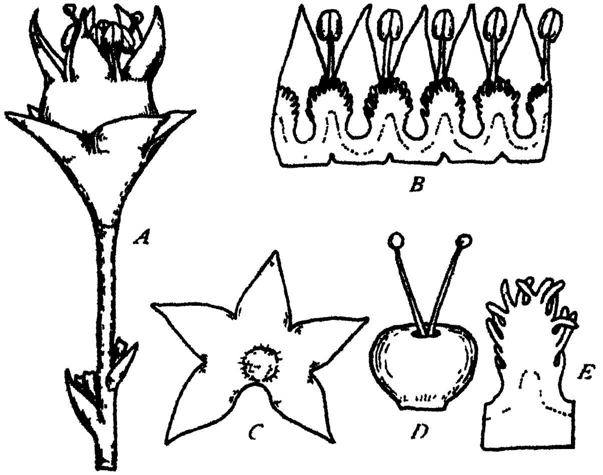

FIG. 1. *Cuscuta colombiana* Yuncker. *A*, flower, × 12; *B*, opened corolla, × 12; *C*, opened calyx, × 12; *D*, young capsule, × 12; *E*, scale, × 24.

Specimens examined. COLOMBIA, Dept. Magdalena: Open grass-land at Alto de Minas, alt. about 300 m., on *Euphorbia* sp., October 10, 1944, Oscar Haught *no. 4400* (type, in U. S. Nat. Herb.); on drying herbs, vines and under-shrubs, near Riohacha, alt. 30 m., Dec. 24, 1944, Oscar Haught *no. 4536* (U. S. National Herbarium).

This species appears to belong in the subsection Umbellatae of section Eugrammica and is mostly closely related to *C. gracillima* Engelmann and *C. saccharata* (Engelm.) Yuncker of Mexico and Central America. It is noteworthy because of the dense, globose clusters up to 3 or 4 cm. in diameter, and the marked cup and saucer appearance of many of the flowers caused by the spreading calyx lobes. No matured capsules were observed but the immature fruit gave evidence of eventually breaking away near the base in an irregular line of circumscission.

It differs from *C. saccharata* because of its smoother flowers and from *C. gracillima* because of its shorter stamens and styles and from both because of the spreading calyx lobes.

Recently Dr. T. H. Kearney raised the question relative to the proper authority for the name *Cuscuta californica,* which has been commonly credited to Choisy who published it in the Mémoires de la Société de Physique et d'Histoire Naturelle de Genève **9**: 279, 1841–42. Hooker and Arnott used the same name for the same species on page 364 of their *Botany of Captain Beechey's Voyage*, dated 1841. Choisy's paper carries the notation that it was communicated January 21, 1841, which would appear to be the reason for assuming that Choisy had priority. In checking to determine the exact dates of publication of these two papers, I am indebted to Dr. H. W. Rickett who states that Choisy's paper very probably did not actually appear until 1842 and also that the part of Beechey's Voyage containing page 364 came out in 1838. This clearly indicates that Hooker and Arnott have priority as authors for the name of this common western species.

In 1935 I published (Bull. Torrey Club **62**: 512) a new variety of *Cuscuta deltoidea* Yuncker under the name *serrulata.* Later (ibid. **69**: 542, 1942), I described and figured *Cuscuta serruloba* as a new species. At that time I did not recognize the relationship of this new species with my formerly described variety. More abundant material has recently come to hand, however, which shows that they are the same. The evidence for specific rank is also strengthened, so this plant should now be known as *Cuscuta serruloba* Yuncker.

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DALEA EMPHYSODES, AN INVALID NAME

ROBERT T. CLAUSEN

Mr. F. J. Hermann has kindly brought to my attention the fact that *Psoralea emphysodes* Jacq., on which the combination *Dalea emphysodes* is based, is a later synonym of *Psoralea carthaginensis* Jacq. Enum. Syst. Pl. Carib. 27 (1762). Killip (Jour. Wash. Acad. Sci. **26**: 359. 1936) indicated the essential synonymy of this species and published the combination *Parosela carthaginensis*. Unfortunately, I overlooked Killip's publication, also Macbride's paper (Field Mus. Pub. Bot. **13**^{3}: 375. 1943) in which he made the combination *D. carthaginensis*. The three subspecies which I recently designated under *D. emphysodes* should now be transferred to *D. carthaginensis* (Jacq.) Macbride, with the nomenclaturally typical subspecies, with the lobes of the calyx straight, to include *Psoralea emphysodes*.

DALEA CARTHAGINENSIS subsp. **typica** R. T. Clausen, nom. nov., based on *Psoralea carthaginensis* Jacq. *loc. cit.* The synonymy is listed under *D. emphysodes* subsp. *emphysodes* (Jacquin) R. T. Clausen, Bull. Torrey Club **73**: 85 (1946). *D. trichocalyx* Ulbrich possibly also should be included here. I am purposely using the epithet *typica* in order to abide by recommendation 18 under article 30 of the International Rules of Botanical Nomenclature, which states that botanists should avoid giving a new epithet to any subdivision of a species which includes the type either of a higher subdivisional name or of the specific name. They should either repeat that epithet, with or without a prefix, or use one of the customary epithets, *typicus, genuinus, originarius,* etc. Since the use of the subspecific epithet *emphysodes* here would violate this recommendation because it is based on a type different from that of the specific epithet, also since the use of *emphysodes* would create ambiguity, thus violating article 4 of the Rules, the designation of the typical subspecies as *typica* seems justified.

DALEA CARTHAGINENSIS subsp. **domingensis** (DC.) R. T. Clausen, comb. nov., based on *Dalea domingensis* DC. Prodr. **2**: 246 (1825). The synonymy is listed under *D. emphysodes* subsp. *domingensis* (DC.) R. T. Clausen, *loc. cit.*

DALEA CARTHAGINENSIS subsp. **thyrsiflora** (A. Gray) R. T. Clausen, comb. nov., based on *Dalea thyrsiflora* A. Gray, Proc. Am. Acad. **5**: 177 (1861). The synonymy is listed under *D. emphysodes* subsp. *thyrsiflora* (A. Gray) R. T. Clausen, *loc. cit.*

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THE ROLE OF CERTAIN ENVIRONMENTAL FACTORS IN GROWTH AND REPRODUCTION OF PROTOSIPHON BOTRYOIDES KLEBS—I. RACES, STRAINS AND CLONES[1]

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Adjarof in 1905 noted that the lower organisms and especially the green algae lend themselves to the most varied experiments. They have attracted the attention of botanists either from the point of view of the conditions of their nutrition or the relations between nutrition and the modifications of internal and external morphology, and also because of the importance of the organisms in the development of the species-concept.

Protosiphon Klebs is a genus of Chlorophyceae which is included in the Chlorococcales by West and Fritsch (1927), Printz (1927), Brunnthaler (1915) and Oltmanns (1922). Setchell and Gardner (1920), West (1916) and Bold (1933) prefer to include it among the Siphonales. *Protosiphon* lends itself to experimentation to an exceptional degree because of the readiness with which it responds to changes in environment and the certainty with which a given form or stage can be evoked.

Moewus (1933, 1935a, b) reached interesting conclusions regarding the effect of certain environmental factors on this as well as on some other organisms. Twenty-two of the experiments performed by him (1935b) on *Protosiphon* were analyzed by Philip and Haldane (1939) who calculated that "if every member of the human race conducted a set of experiments of this type daily, they might reasonably hope for such a success once in fifty thousand million years." They state that one alternative to the hypothesis of chance is the presence of a wholly new type of biological regulation that controls the frequency of segregation with extreme sharpness and that this applies to three segregations in two species. The other is that the author has consciously or unconsciously adjusted his observations to fit his theory. They suggest that the importance of the work for the theory of sex-determination calls for a repetition of the work by an independent worker. Sonneborn (1941) says that the failure of Pringsheim and Ondraček (1939) in their attempt to confirm certain points of the work of Moewus, their numer-

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[1] This work will appear in three parts; a list of literature cited will be found in part III.

[2] The author is indebted to Dr. Harold C. Bold who directed this study.

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ous criticisms, the criticisms of Philip and Haldane (1939), internal inconsistencies in the data listed by Moewus, and the great theoretical importance of the work make an independent repetition of it an urgent need.

The present study is not an attempt to repeat completely the work of Moewus, but it is a step that should be helpful when such an attempt is made. The objective was to study the effect on the growth and reproduction of *Protosiphon* of various environmental conditions with a view to determining, if possible, optimum cultural conditions. The influence of such factors as temperature, age of cultures, and the hydrogen-ion concentration of media on gamete formation have been considered, and some attention has been given to factors that induce conjugation.

MATERIALS AND METHODS

Origin of Races. The *Protosiphon*-race designated by *B* was kindly supplied by Dr. Harold C. Bold from the material used by him in his work on the life history and cytology of *Protosiphon* (1933). Moewus (1933) also employed this race in some of his experiments.

Soil samples were obtained from Syracuse, N. Y.; Scranton, Pa.; Virginia and Nebraska. Cultivated soil from the surface layer was taken at various times of the year. From such a sample, about 5 g. of soil were added to 40 ml. of sterile nutrient solution in a 50 ml. flask. The flasks were plugged with cotton stoppers and allowed to stand near a window or in artificial light until there was visible green color on the sides. With the aid of a binocular dissecting microscope with lenses giving a magnification of 60 diameters, and very fine platinum needles, algae were removed to solid nutrient media. At first many species of algae were present but as soon as the characteristic thalli of *Protosiphon* appeared, they were separated from the other varieties by means of platinum needles, so that unialgal cultures were secured. Transfers were repeated until bacteria and other fungi were eliminated. A quicker method is to tease out coenocysts from sacs with fine dissecting needles (Schramm 1914). The coenocysts are then washed with agar of 1 per cent concentration and transferred to fresh agar. It was found that coenocysts could be washed and transferred with platinum needles more readily from agar than from water. Absolutely pure cultures were used in the experiments. The purity was tested by microscopic examination and by growing the cultures from time to time on media containing glucose or inulin.

Isolation of Clones. The progeny of a single plant (cell or sac) (fig. 12) is called a strain. A sac from a strain culture was placed in a drop of distilled water on the surface of nutrient agar in a Petri dish. The dishes were subjected to a temperature a few degrees above that of the room until the contents had formed motile swarmers which had not yet escaped. This requires about four to six hours depending on the temperature and the condition of the plants. Such a sac is then picked up with a platinum needle and drawn over the surface of agar in a Petri dish; as a result of such manipulation the sac is ruptured and the gametes are spread out on the surface and are unable to conjugate. A thin layer of agar was used so that with the aid of a microscope the position of some gametes could be marked and their development kept under observation. Unfused gametes begin development more quickly than zygotes and, with 0.125 per cent glucose added to the nutrient agar, they were large enough in four or five days to be transferred easily to individual plates of nutrient agar. Bold (1933) has demonstrated that the potential gametes (swarmers) each contain one nucleus. The culture that develops from a single unfused gamete is called a clone or clonal culture.

In this study absolutely pure clonal cultures have been used exclusively. For convenience in referring to them, they have been assigned a letter to designate the source. Moewus (1935b) applied the term race to the plants obtained from a given locality and it is used in the same way in this paper. The figure preceding the letter is the number of the strain and the figure following the letter is the number of the clone from that strain. For example, 7*B*2 refers to the second clone taken from strain 7 of the *Bold* race. The Marywood race designated by *M* was taken from soil collected in Scranton, Pennsylvania. Cultures taken from soil samples collected in Syracuse, New York, are marked *S*. *N* and *V* refer to cultures from Nebraska and Virginia.

Optimum Cultural Conditions and Media. Pyrex glassware was used exclusively. Petri dishes, flasks, and test tubes were first washed with sulfuric acid-potassium dichromate mixture. Bacteriological technique was employed

Optimum development of the sacs in all the strains was secured at a temperature of 19° C or below. Higher temperatures particularly when combined with excessive moisture evoke continuous formation of gametes, and a corresponding lack of large, well developed sacs. It was found necessary to keep the cultures in a cool place with a light source similar to that described by Bold (1936).

Uniformly good results were secured when *Protosiphon* was cultured in Bristol's solution (1919) modified by substituting dipotassium phosphate for some of the monopotassium phosphate in the original formula. This gives a solution that has a lower hydrogen-ion concentration than one prepared according to the original formula. The formula employed is as follows:

K_2HPO_4	0.3 gram	NaCl	0.1 gram
KH_2PO_4	0.7 gram	$CaCl_2$	0.1 gram
$NaNO_3$	1.0 gram	Distilled water	1000.0 ml.
$MgSO_4$	0.3 gram		

One drop of 1.0 per cent $FeCl_3$ solution was added to each liter of the medium, and 2 ml. of minor elements solution (Craig & Trelease 1937), as well as 1 ml. of molybdic acid solution (30 mg. of 85% molybdic acid in 1000 ml. of distilled water). Three volumes of water were added to one volume of this medium so that the concentration used is 0.06 per cent by weight-volume. The water was redistilled through a Pyrex glass condenser.

Whenever not otherwise stated, two series, one in solid media and the other in liquid media were set up for each experiment. Six Erlenmeyer flasks of 50 ml. capacity and each containing 40 ml. of solution were used for the experiments with liquid media. In later experiments, because it was found more convenient for centrifuging, 35 ml. of liquid media were used. Six slants containing the same solution as the flasks, solidified with 1.5 per cent agar were used as a parallel series.

Plants for inoculation were taken from cultures grown for two weeks on modified Bristol's solution described above and solidified with 1 per cent agar. One loopful of the plants was streaked on each slant and one loopful was added to each flask.

Growth on agar was estimated by gross appearance and by measuring one hundred sacs with an ocular micrometer. Color changes from green to red indicate that the plants have stopped growing and are forming coenocysts.

Observations were also made as to the size and appearance of sacs growing in liquid cultures. An arbitrary set of color standards was set up and the color intensity recorded as 1, 2, 3, etc. The total quantity of growth in liquid was determined by centrifuging and measuring with the aid of graduated tubes (hematocrit method).

REVIEW OF LITERATURE

Klebs (1896) and Moewus (1933, 1935b) among others have published extensive accounts dealing with the influence of the environment on reproduction and on sexuality in *Protosiphon*. Their observations, in so far as they bear on the present study, have been summarized in tabular form (tables 1, 2). Their disagreement on such points as the influence of concentration of the medium and temperature on gamete formation and fusion is apparent from a comparison of tables 1 and 2.

Oltmanns (1922) stated that gametes can be formed in about three hours at 20°–26° C, but that they do not copulate if the temperature is increased to 26° or 27° C. He reports that coenocysts are formed by such causes as drying of the substratum, intensive sunlight and increasing temperature.

Moewus (1933) reported a series of experiments with residual gametes of *Protosiphon botryoides*. The presence of zygotes on slides to which single sacs had been transferred indicated that the organism is monoecious. A number of plants were placed singly in each of ten Boveri dishes. Zygotes were formed and remained on the bottom of all the dishes and unfused gametes gathered on the lighted side. These continued to be motile for 15 hours. During this time unfused gametes from the dishes were combined in all possible ways. The residual gametes from seven dishes were found to be of one sex and those from the other dishes belonged to the other sex. Fusion occurred when gametes of unlike sexes were combined. Moewus interpreted this as indicative of physiological differentiation in an alga with phenotypic sex determination.

TABLE 1. *Effect of environmental factors on the growth and reproduction of Protosiphon botryoides as reported by Klebs (1896).*

Factor	Effects on		
	Vegetative growth and formation of coenocysts	Gamete formation	Conjugation of gametes
Concentration of nutrient solution	In dilute solution cells were globular or club-like in form. Best development in 1.0% nutrient solution.	Transferring cells to water or to fresh nutrient solution of 0.4% or even 1.0% caused swarmer formation. Increasing the concentration slowed the process. Adding 1.0% to 2.0% sucrose accelerated it.	Took place readily in water, was retarded when concentration was increased. Very slow in 1.0% inorganic solution. 1.0% sucrose or of many other sugars accelerated copulation.
Light	In weak light, cells remained small and there was no separation of lobes and branches by septa. Bright sunlight hastened the formation of coenocysts and was requisite for their formation if the cells were in pure water.	Dim light or darkness induced swarmer formation in growing cells. Light hastened the formation of swarmers from coenocysts.	Conjugation was retarded by darkness.
Temperature	Increase of temperature promoted formation of coenocysts when food supply was sufficient.	Time required decreased gradually from 24–48 hours at 4°–6° C to 2½–3 hours as the temperature increased to 23°–26° C. At low temperatures the process continued for many days.	Temperatures of 26°–27° C rob swarmers of ability to conjugate. Swarmers formed at 0°–1° C conjugated but those brought from the warming oven to lower temperatures did not.

Later (1935b), Moewus worked with eleven races of *Protosiphon* that were obtained from different localities. Some of these were monoecious and others dioecious. In some cases he reported that sex determination was genotypic and in others phenotypic. He states that the *B* (Bold) race is dioecious and that the gametes of a single clone never fuse. When germinating zygotes with eight nuclei were transferred to agar and allowed to form zoospores, four of the clones obtained from such a zygote were negative and four were positive. He reports that reduction takes place when the zygote germinates and with it sexual segregation in a ratio of 1 : 1. He used the + and – gametes of the *B* race to test the sexuality of the other races studied. He states, in a footnote, that it was not determined by Bold (1933) that this same race *B* was genotypically dioecious, and suggests that a mutation may have taken place. He reports that the material was in bad condition after shipment and states that many races of *Protosiphon* easily undergo mutation of sex.

TABLE 2. *Effects of environmental factors on the growth and reproduction of Protosiphon botryoides (from Moewus 1933, 1935b).*

Factor	Effects on		
	Vegetative growth and formation of coenocysts	Gamete formation	Conjugation of gametes
Concentration of solution	Largest sacs were produced in 0.5% Kolkwitz' solution with 0.7% agar. On 1½% agar the cells remained small and tended to produce coenocysts. Lack of food and lack of water induced formation of coenocysts.	Gametes were produced in tap water, distilled water, 1.0% Kolkwitz' solution and 1.0% Sorbit solution.	Copulation in all solutions in which gametes were produced and in solutions with concentrations twenty times higher.
Light	Cultures grew equally well in artificial light or in natural light from a window.	No effect. Gametes formed in four or five hours in light or in darkness.	No effect. Gametes copulated in darkness as in light if other conditions were satisfied.
Temperature	Temperatures over 30° C accelerated formation of coenocysts.	No effect on time required for gamete formation. Between 7° C and 28° C gametes were always produced in four to five hours after plants were transferred to liquid.	All swarmers could copulate between 2° C and 28° C (1933). At temperatures higher than 18°–19° C an increase in the number of + residual gametes (1935a).
pH	Good growth between pH 4.5 and pH 9.5.	In acid media more + than – gametes were produced. In alkaline media, more – gametes were produced. With culture and gamete formation at pH 7, and a temperature of 18° to 19° C equal numbers of + and – gametes were produced.	Following culture and gamete formation at pH 4.5, there was little conjugation and most of the residual gametes were +. At pH 7.0, there was much conjugation and the temperature determined whether the residual gametes would be + or –. Below 18° C, – gametes were more numerous, above 18° C, + gametes were more numerous.

The basic problem of sexuality according to Sonneborn (1941) is whether the copulating or conjugating cells regularly differ from one another. Fritsch

(1935) states that fusion between the gametes of the same parent individual is rare. If this be true, then the majority of isogamous algae are dioecious. If the copulating gametes are not diverse physiologically, then any two gametes can copulate with one another, but if they are regularly diverse, there must be at least two kinds of gametes with copulation between gametes of different types.

Pringsheim and Ondraček (1939) attempted an experiment with residual gametes of *Protosiphon*. They used plants that were from three days to two months old. Plants were transferred to a number of different solutions and the dishes placed in window light, in artificial light, in darkness and then in light. The results were always the same. In the first hours there were few gametes. Gradually they became more numerous and copulation began while additional gametes were being formed. On the following morning, in all the dishes, there were gametes in group formation and zygotes. The whole process was long and continuous and there were no residual gametes. From the same dishes gametes were transferred on the following day to distilled water in each of ten dishes. Gametes collected on the lighted side of the dishes and after from six to seven hours, there was strong copulation. After a few more hours, there were only a few swarmers and no residual gametes. Pringsheim and Ondraček suggest that residual gametes are left over only when the conditions for copulation are unsuitable. They were unable to confirm Moewus' (1935) results.

OBSERVATIONS

Character of the Races. As a preliminary to the study of the influence of individual environmental factors, a comparative study of the various races was undertaken. The observations are summarized in tables 3, 4, and 5.

The B Race. The general features of the structure and reproduction of *Protosiphon botryoides* have been made known through the studies of Cienkowski (1855), Rostafinski and Woronin (1877), and Klebs (1896). The life history and cytology were worked out by Bold (1933).

Protosiphon botryoides Klebs is found associated with *Botrydium* on damp soil. Under suitable conditions, the aerial portion of a single plant may extend 0.5 mm. above the surface of the substratum with the unbranched rhizoid penetrating the soil to a depth of 1 mm. The aerial portion may be branched, but the subterranean rhizoid is unbranched, in contrast with that of *Botrydium*.

The central part of the thallus is occupied by a large central vacuole or a series of vacuoles. These are surrounded by a layer of protoplasm that becomes very thin in the colorless rhizoidal part. The plant is uninucleate only during reproduction. It becomes multinucleate very early in its development and the nuclei are distributed between the plasma membrane and the tonoplast. Pyrenoids are present both in the peripheral and the deeper protoplasm. The protoplasm of young thalli and young coenocysts is characteristically vacuolate.

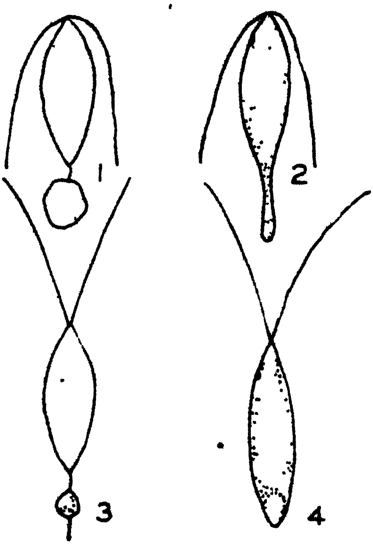
Reproduction is accomplished by separation of lobes and branches from young parent plants, by septa, and by formation of gametes from thalli and from coenocysts. The gametes can grow directly into new plants or they may fuse in pairs to form thick-walled zygospores. The zygospores may develop after a period of dormancy into new thalli. Gametes that are not liberated from the parent plant develop walls within it and by their growth into thalli eventually rupture the mother thallus wall.

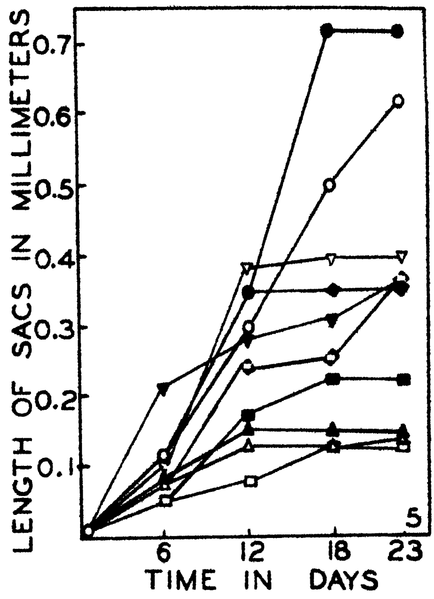
Under conditions of drought and bright sunlight, the thallus protoplast segments into multinucleate coenocysts. These, after a period of time that depends upon the cultural conditions, develop a red pigment. With moderate moisture, the cysts can develop directly into thalli; if submerged in water they will form gametes.

It has been pointed out by Bold (1933) that it is difficult to induce gamete-formation in very young plants, but that those grown on agar for 12–15 days invariably produce them when the thalli are submerged in water. The protoplast becomes less vacuolate and more densely green and granular. The protoplast shrinks and the pyrenoids are obscured; the contour of the surface appears lobed and folded and the protoplast is divided into small segments by progressive cleavage. During these changes there is no nuclear division, but preceding the final division of the protoplast, one or two nuclear divisions take place. After this final bipartition, the segments withdraw from each other, increase slightly in size and develop into gametes. Two equal flagella develop from a deeply staining granule, the blepharoplast, that appears between the plasma membrane and the nucleus. The pyrenoid may disappear during gametogenesis and be formed de novo after the gamete comes to rest.

When first liberated, the gametes may be globose, but they soon become spindle-shaped. A few attain the length of 11 μ but the majority are between 3 and 6 μ in length. Both ends are colorless and pointed. Newly formed gametes often have what appear to be pieces of protoplasm attached to the posterior end (figs. 1–3); these are gradually lost during motility. Some have a hyaline droplet at the posterior end (fig. 4). A pyrenoid may or may or may not be present, but all the gametes possesses a red eyespot. The two flagella are about as long as the body. Gametes tend to collect near the edge of a drop and to become angular by mutual contact (fig. 14). They collect in a similar way on solid media and the pole not in contact with the substratum enlarges in a direction perpendicular to the surface of the medium.

As the gametes swim about, many become attached to one another by the flagella and begin to fuse in pairs. The completely fused gametes may continue motile for some time and during this period they exhibit the same phototactic and aerotactic responses as the unfused gametes with which they intermingle at the edge of the drop. Stigmata and contractile vacuoles are present in double numbers when the zygotes come to rest, but they eventually disappear. The zygotes form a thick wall and become star-shaped zygospores. When the zygospores are transferred from an old culture to fresh media, their contents swell and the thickening of the wall becomes less apparent as the cells increase in size. After the outline becomes more regular, growth is greater along one axis; the zygospore becomes sac-shaped and develops into a typical thallus.





Figs. 1–3. Diagrams of zoospores of *Protosiphon* with bits of protoplasm attached to the posterior end. Fig. 4. Diagram of a zoospore with a hyaline droplet at the posterior end. Fig. 5. Graph to show cell size and growth of sacs from clones of different races of *Protosiphon* grown on 0.06 per cent Bristol's solution solidified with 1.5 per cent agar. Length of sacs from clone:

—○—	8*B*2	without	inulin	—●—	8*B*2	with	inulin
—▲—	5*M*3	”	”	—▲—	5*M*3	“	“
—□—	2*N*6	”	”	—■—	2*N*6	“	“
—◆—	6*S*3	”	”	—◆—	6*S*3	“	“
—▼—	2*V*7	”	”	—●—	2*V*7	“	“

Coenocysts arise by the centripetal growth of furrows that originate at the plasma membrane, and progress through the cytoplasm. Zoospore formation in either red or green coenocysts is essentially the same as for the thalli.

These observations made by Bold (1933) were confirmed in the present investigation of the same race.

Other Races. Two series of clonal cultures from the *B, M, N, S* and *V* races were set up under identical conditions for comparative study. The medium was modified Bristol's solution. Six flasks each with 35 ml. of liquid and six slants with the same medium solidified with 1.5 per cent agar were used for each clone. The same medium in both solid and liquid form, but with the addition of 0.5 per cent inulin, was used for the second series.

Data for the cultures grown on solid medium are summarized in table 3 and figure 5. Table 4 summarizes data for cultures grown in liquid media.

TABLE 3. *Cell size in clones from different races of Protosiphon grown at a temperature of 17° C, on 0.06 per cent Bristol's solution solidified with 1.5 per cent agar.*

A. Without inulin

Clone	Mean length of 100 sacs after			
	6 days	12 days	18 days	23 days
8*B*2	0.12 mm.	0.3 mm.	0.5 mm.	0.62 mm.
5*M*3	0.08 mm.	0.13 mm.	0.13 mm.	0.14 mm.
2*N*6	0.05 mm.	0.08 mm.	0.13 mm.	0.13 mm.
6*S*3	0.08 mm.	0.24 mm.	0.25 mm.	0.37 mm.
2*V*7	0.10 mm.	0.38 mm.	0.40 mm.	0.40 mm.
B. With 0.5 per cent inulin				
8*B*2	0.12 mm.	0.35 mm.	0.72 mm.	0.72 mm.
5*M*3	0.09 mm.	0.15 mm.	0.15 mm.	0.15 mm.
2*N*6	0.08 mm.	0.17 mm.	0.22 mm.	0.22 mm.
6*S*3	0.11 mm.	0.35 mm.	0.35 mm.	0.35 mm.
2*V*7	0.21 mm.	0.28 mm.	0.31 mm.	0.37 mm.

The sacs from clone **8*B*2** were longer than those from any of the other clones. Sacs with a length of 0.72 mm. measured from 0.05 to 0.07 mm. at the widest part thus being from ten to fourteen times as long as their greatest diameter. From one-fourth to one-sixth of the length of the sacs contained chlorophyll and the remainder consisted of clear rhizoidal portion (fig. 6). Practically all of the sacs of clone 8*B*2 as well as those of all the other clones that were grown on inorganic medium contained coenocysts after 23 days, while many in the solutions with inulin were still in vegetative condition.

Sacs from clone 5*M*3 (fig. 7) are always much shorter than those from the *B* race. The mean length of sacs from clone 5*M*3 was less than one-fourth the mean length of those in 8*B*2. Some cells did not elongate but remained spherical. When the plants are grown at a temperature above 19° C, spherical cells are more numerous than they are at lower temperatures. Results with regard to comparative size of sacs were similar regardless of the medium

TABLE 4. *Growth of clones from different races of Protosiphon in 0.06 per cent Bristol's solution (liquid form) at a temperature of 17° C.*[a]

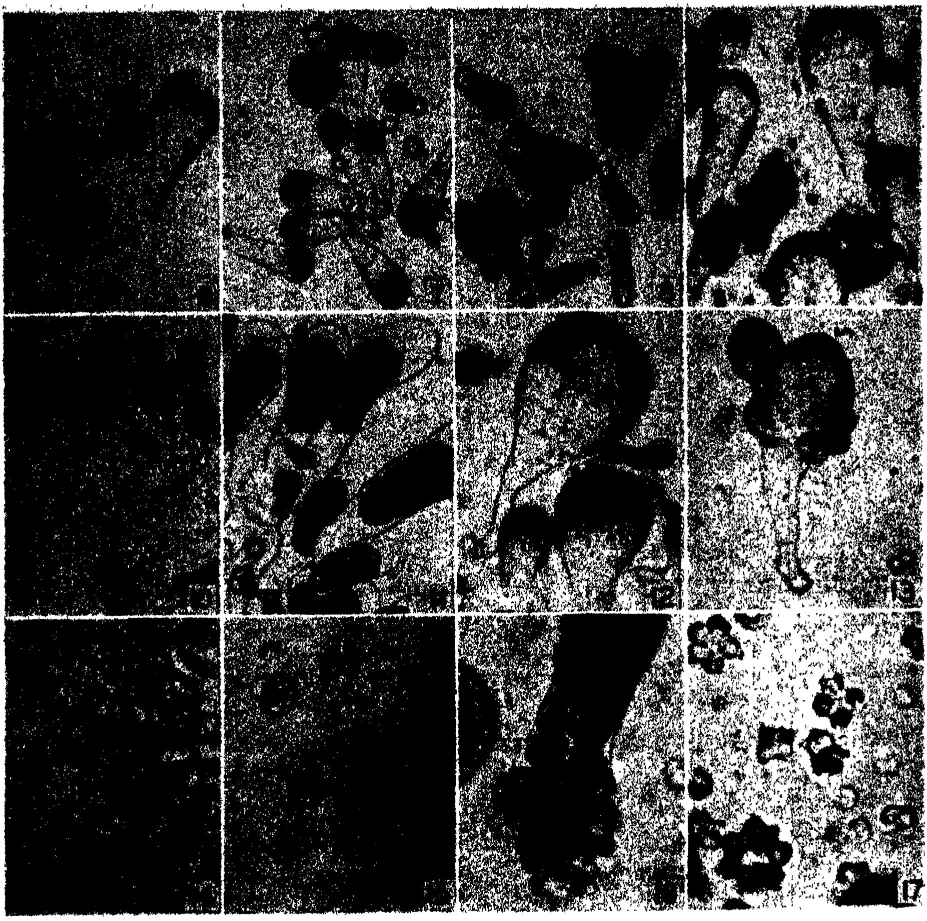
A. As determined by volume of centrifugate

Clone	Medium	pH		Color intensity	Volume centrifuged from one flask
		At beginning of experiment	At end		
8*B*2	0.06% B.	6.8	7.0	1+	0.04 cc.
	0.06% B. + inulin	6.5	7.0	2	0.05 cc.
5*M*3	0.06% B.	6.8	7.5	1	0.03 cc.
	0.06% B. + inulin	6.5	7.4	1	0.03 cc.
2*N*6	0.06% B.	6.8	7.2	1	0.03 cc.
	0.06% B. + inulin	6.5	7.2	1+	0.03 cc.
6*S*3	0.06% B.	6.8	7.4	1	0.03 cc.
	0.06% B. + inulin	6.5	7.4	1+	0.03 cc.
2*V*7	0.06% B.	6.8	7.4	1	0.01– cc.
	0.06% B. + inulin	6.5	7.4	1	0.02 cc.

B. As determined microscopically

Clone	Medium	Observations
8*B*2	0.06% B.	The sacs were nearly all in vegetative condition. Many cells were spherical and many were thin sacs 0.75 mm. long. Gametes were present, also a few zygotes.
	0.06% B. + inulin	Vegetative sacs were 0.6 mm. long. Gametes were present but no zygotes were observed.
5*M*3	0.06% B.	Most cells were spherical. Gametes and a few zygotes with four to six points were observed.
	0.06% B. + inulin	As in the culture without inulin, cells were spherical, but there were fewer zygotes.
2*N*6	0.06% B.	Many single coenocysts were present. Zygotes were not numerous. Most of them had four or five points.
	0.06% B. + inulin	Most of the cells were small and contained single coenocysts. Zygotes were less numerous than in inorganic medium.
6*S*3	0.06% B.	Most of the cells were small and contained single coenocysts. A few sacs were 0.25 mm. long, a very few zygotes were present.
	0.06% B. + inulin	Sacs 0.35 mm. long in vegetative condition fairly numerous. Some spherical cells in vegetative condition and with a diameter of 0.1 mm. Some zygotes with four, five and more points.
2*V*7	0.06% B.	Masses of zygotes with four, five or more points. There were few vegetative cells and this seems to account for the relatively small amount of centrifuged material.
	0.06% B. + inulin	Zygotes extremely numerous, with four, five and eight points and a diameter of 5 to 10 microns (fig. 17). One sac filled with zygotes was found in this culture (fig. 16).

[a] pH at the beginning of this experiment was determined colorimetrically, the determination at the end was made by use of a glass electrode.



Photomicrographs of *Protosiphon*, taken with a Leitz "Macca" camera. Figs. 6–8 and 10–13 × 100. Fig. 9 × 50. Figs. 14, 15, 17 × 675. Fig. 16 × 440. The thalli were grown on 0.06 per cent Bristol's solution at a temperature of 16°–19° C. FIG. 6. Sacs from clone 8*B*1 grown for two weeks on medium solidified with 1 per cent agar. FIG. 7. Sacs 0.13 mm. long from clone 5*M*3, grown 18 days on medium with 1.5 per cent agar. FIG. 8. Sacs from clone 5*M*3 with coenocysts (from the same culture as sacs shown in figure 7) after 23 days. FIG. 9. Sacs 0.55–0.60 mm. long from 2*N*6 grown four weeks with 0.25 per cent glucose and 1 per cent agar. FIG. 10. Sacs from clone 6*S*3 grown for 12 days on medium solidified with 1.5 per cent agar. FIG. 11. Sacs from the same culture (6*S*3) as those shown in figure 10 after 18 days growth. FIG. 12. Sacs from 2*V*7 grown for 18 days on medium solidified with 1.5 per cent agar. The sac in the center of the figure is 0.31 mm. long and 0.16 mm. in diameter. FIG. 13. Sac with buds from 2*V*7 after 21 days. FIG. 14. Living swarmers from clone 5*M*3 produced when plants were immersed in 0.06 per cent Bristol's solution. Note the prominent eyespot. FIG. 15. Swarmers from 2*N*6 stained with iodine. Note the darkly staining inclusions. FIG. 16. A sac with zygotes from a culture of 2*V*7 growing 31 days in 0.06 per cent Bristol's solution (liquid). FIG. 17. Zygotes of various shapes and sizes centrifuged from the same culture of 2*V*7 as the sac shown in figure 16.

used. Sacs from 7*B*2 were more than six times as long as those from 5*M*3 after cultures from both clones had grown for 25 days on 0.06 per cent Pringsheim's solution solidified with 1 per cent agar. The addition of inulin did not make a significant difference in the length of sacs from 5*M*3 as it did in the case of 6*B*2 (table 3). In mature sacs of 5*M*3, coenocysts 40 μ in diameter occupied most of the cell lumen (fig. 8).

Cultures of 2*N*6, on inorganic medium, resembled those of 5*M*3. After six days most of the cells were spherical. Single coenocysts or sacs containing one or two coenocysts were numerous after 12 days. After 18 days, most of the sacs contained coenocysts measuring from 25 to 28 μ in diameter. With 0.5 per cent inulin, sacs from clone 2*N*6 were nearly twice as long after 18 days as they were in inorganic medium. The effect of the addition of carbohydrate to medium used for the growth of this clone was marked in a culture that was grown for four weeks on 0.06 per cent Bristol's solution with 0.25 per cent glucose solidified with 1 per cent agar (fig 9). The mean length of 100 sacs in the culture with glucose was 0.42 mm. Approximately half the length of the larger sacs was chlorophyll-bearing. The greatest diameter was from one-third to two-thirds of the length. Many spheres 0.12 mm. in diameter and some larger ones up to 0.3 mm in diameter were present.

Clone 6*S*3 produced broad sacs (fig. 10) that did not grow as long as those from clone 8*B*2. Those in inulin had already reached their greatest elongation after 12 days. Those in inorganic medium grew more slowly but the mean length after 23 days was slightly greater than for those with inulin. After 18 days, most of the sacs in both series of cultures contained coenocysts. Most of the coenocysts had a diameter of 30 μ (fig. 11).

Sacs of clone 2*V*7 had a diameter that was from one-fifth to one-half their length (fig. 12). The distinguishing characteristic of this culture is the peculiar budding from the top and sides of the cells that became very noticeable after the plants were growing three weeks. This appearance has been observed in other cultures of this race but it has not been seen in cultures from other races. The buds (fig. 13) did not separate completely from the mother cell, but each one formed a group of coenocysts that was not in contact with the groups formed in other buds of the same plant or with the group in the mother plant. Coenecysts in this culture varied in diameter from 20 to 40 μ.

The various races exhibit differences in the readiness with which they form gametes and in the structure of the gametes (table 5). A number of attempts to induce gamete formation by the *M* race showed that very few gametes were produced when the plants were immersed in liquid and kept at room temperature. Plants seventeen days old were immersed in 0.06 per cent Bristol's solution and kept under observation for three days without any evidence of gamete formation. Plants from the *B* race immersed in the same liquid and kept under the same conditions produced many gametes; some gametes could always be obtained when plants in suitable condition were immersed in liquid and exposed to a temperature of 25°–29° C for 4–6 hours. Under any conditions, however, gametes were never produced as rapidly from plants of the *M* race as from those of the *B* race.

Gametes illustrated in figure 14 were obtained when plants of clone 5*M*3 were submerged in 0.06 per cent Bristol's solution with the addition of 1 per cent sucrose. Six hours later many gametes were already conjugating. The prominent eyespot that distinguishes gametes of this race can be seen in the figure. The gametes varied in length from 7 to 17 μ; individuals that measured 15 μ in length appeared to be most numerous. No relation between size and ability to copulate could be seen. Individuals of the same size and pairs of gametes differing greatly in length could be seen in all stages of copulation. No pyrenoids were observed when gametes of the *M* race either from organic or inorganic medium were stained with iodine.

TABLE 5. *Summary of data concerning gametes from different clones of Protosiphon botryoides.*

Clone	Length of gametes	Presence of stigma	Presence of pyrenoid	Time required for gamete production under same conditions	Zygotes
8*B*2	6½–15 μ	+	+, –[a]	4–6 hrs.	Produced readily. Zygotes with 3–6 points.
5*M*3	7–17 μ	+ (Very prominent)	–	4–6 hrs.	Gametes produced slowly and zygotes less numerous than in clones from race *B*. Zygotes with 4–6 points.
2*N*6	12–13 μ	+	+, –	4–6 hrs.	Produced fairly readily with 4–5 or more points.
1*T*6	5–15 μ	+	+, –	4–6 hrs.	Produced more readily than in any other race. 4–8 points.

[a] +, – Present in some but not in others.

Gametes were numerous five hours after plants from clone 2*N*6 29 days old were transferred either to water or to 0.06 per cent Bristol's solution in depression slides. They were more numerous in depression slides kept at 29° C for one and one-half hours than they were in slides kept at 22.5° C. A number of deeply staining inclusions appeared when these cells were stained with iodine (fig. 15). Some gametes from clone 1*N*1 that were produced when plants were submerged in 0.06 per cent Bristol's solution showed a pyrenoid when the cells were stained with iodine and others did not.

Gametes were produced five hours after plants from clone 6*S*3 were transferred to water in depression slides at a temperature of 22° C. They were much more numerous when the slides were kept at 29° C for one and one-half hours at 27° C for four hours. Zygotes were more numerous around the edges of the slides that were subjected to heat than they were in slides that were kept at a lower temperature. The length of the gametes varied from 7 to 13 µ. Staining with iodine revealed the presence of a pyrenoid in some cells but not in others.

Gametes were produced very readily when plants from clone 1*V*6 were transferred to 0.06 per cent Bristol's solution and kept at 22° C. Gametes 15 µ in length were numerous, but some measured only 5 µ. Masses of zygotes were present on these slides after 24 hours.

These data indicate that various races of *Protosiphon* occur in nature which differ from each other in morphological and physiological details when cultivated under uniform environmental conditions.

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TORREYA

Short Articles and Notes

Tinian Plants Collected by R. S. Cowan. Pacific Plant Studies No. 5.[1] While serving in the armed forces of the United States, Richard Sumner Cowan was able to collect a few plants on Tinian, Mariannas Islands, even though enemy snipers were still active. These specimens are now deposited in the Bishop Museum, Honolulu. The following are noteworthy additions to the flora of Micronesia.

POLYPODIACEAE

Cyclophorus lanceolatus (L.) Alst. (*C. adnascens* Desv.), epiphytic on trees, March 28, 1945. New to Tinian.

EUPHORBIACEAE

Jatropha gossypifolia L., shrubby, dry cliff, April 10, 1945. New to Micronesia. This species was introduced from South America and was evidently cultivated or an escape from cultivation. It also now occurs in the Philippines and the Marquesas.

VERBENACEAE

Callicarpa cana L., dry beach, April 3, 1945. New to Tinian.—Harold St. John.

New and Interesting Plant Records. The European masterwort, *Imperatoria ostruthium* L., is recorded in current manuals as being established in New York, Pennsylvania, Michigan, and Newfoundland. On June 9, 1946, a large stand of this plant, about half an acre in extent, was found in fields at Scotch Plains, Union County, New Jersey, *H. N. Moldenke 18288*.

The large yellow-flowered European vetch, *Vicia grandiflora* var. *sordida* Griseb., has been found by Harry Ahles in an orchard and along margins of woods, completely naturalized, at Bedford, Westchester County, New York. The determination has been checked by Dr. P. L. Ricker.

The same collector has recently found *Persicaria tomentosa* (Schrank) Bicknell, a species with the lower leaf-surfaces densely pubescent, in ashes along a railroad track at Pelham Bay Park, Bronx County, New York, June 7, 1946, *H. Ahles 381*.

In Torreya **41**: 192–198 (1941) I reviewed the history and occurrence of *Persicaria longiseta* (De Bruyn) Moldenke in America from the date of its introduction in 1910 to 1941. Since the writing of that paper this species has been found in several additional localities: October 14, 1941—in waste ground, forming large colonies, very showy, New York Botanical Garden, Bronx Park, Bronx County, New York, *H. N. Moldenke 11892;* September 8, 1942—abundant in waste lots, Englewood, Bergen

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[1] This is the fifth of a series of papers designed to present descriptions, revisions, or records of Pacific island plants. The preceding papers were published as Occ. Pap. Bishop Mus. 17(7), 1942; 17(13), 1943; 18(5), 1945; Am. Fern Jour. 35: 87–89. 1945.

County, New Jersey, *H. N. Moldenke 13887;* October 20, 1944—along the Bronx River Parkway near 229th Street, Bronx, Bronx County, New York, collected by Alma L. Moldenke, *H. N. Moldenke 17063;* September 3, 1945—in waste ground. Watchung, Somerset County, New Jersey, *H. N. Moldenke 17996;* October 20, 1945—weed in gardens, Arden, New Castle County, Delaware, collected by Morris Berd, *H. N. Moldenke 18232;* and June 9, 1946—weed in cultivated ground, North Bergen, Hudson County, New Jersey, *H. N. Moldenke 18287.*

Mazus reptans N. E. Br. was found as a weed in lawns near Arden, New Castle County, Delaware, June 1, 1946, *H. N. Moldenke 18269,* det. by F. W. Pennell.

Veronica persica Poir. has been found as a very common weed in lawns and cultivated ground at North Warren and Sheffield, Warren County, Pennsylvania, *H. N. Moldenke 17190, 17191, 17359* [cfr. Am. Midl. Nat. **35**: 376. 1946]. On June 1, 1946, it was again found, this time in lawns at Arden, New Castle County, Delaware, *H. N. Moldenke 18270,* det. F. W. Pennell.

Hartmannia speciosa (Nutt.) Small has been found occasionally as a waif in the eastern states in recent years. On June 15, 1946, it was found by Morris Berd at Arden, New Castle County, Delaware, growing as a weed in a garden, forming a small colony and apparently spreading (*H. N. Moldenke 18299*).

Akebia quinata Decaisne was found in a thicket along a roadside near Cornwall, Orange County, New York, on May 6, 1946 (*H. N. Moldenke 18235*). The vines formed a very dense growth, completely covering the ground, smothering out all herbaceous vegetation, and covering all the shrubs and trees to a height of about 15 feet.

Rhaphanistrum inocuum var. *album* Corbière was collected by H. Ahles on June 17, 1945, along the saltwater inlet near Bridge Road, Pelham Bay Park, Bronx County, New York (*H. N. Moldenke 18295*). Its pure white flowers rendered it quite conspicuous among plants of the normal form. The collector states that both forms were observed in several other near-by localities, the white form sometimes quite abundant.

Centaurea nigra var. *radiata* P. DC. In the current edition of Gray's "Manual" (1908), page 861, this variety is recorded from "N. S. to Ont. and Pa." On July 10, 1946, I found it growing along a waste roadside by a vacant lot in the northern part of the Bronx, Bronx County, New York (*H. N. Moldenke 18353*).—HAROLD N. MOLDENKE.

Another Station for Lactuca stolonifera. In Rhodora **44**: 18. 1942, Mr. E. J. Alexander reported the occurrence of the northeastern Asiatic *Lactuca stolonifera* (A. Gray) Maxim. as a weed in lawns at Flushing, Queens Co., New York, collected by Mrs. Ralph Stoddard. As a footnote to the same article the editors reported the same species as a "pest" in gardens at Media, Delaware Co., Pennsylvania, collected by Mrs. S. P. Williams. On a recent field trip of the Torrey Botanical Club *Lactuca stolonifera* was found in considerable abundance as a weed in gardens and garden pathways and lawns at Arden, New Castle Co., Delaware. Specimens (*H. N. Moldenke 18239*) are being deposited in leading herbaria.—HAROLD N. MOLDENKE.

FIELD TRIP REPORTS

MAY 4. WILLOWBROOK PARK, STATEN ISLAND. A total list of over forty species was compiled in the course of this study. In addition to those promised in the field schedule, *Ranunculus Ficaria* was an unusual plant seen in some abundance. A drive to the vicinity of Moravian Cemetary added many plants associated with the serpentine area there. Leader, Mr. L. A. Ellison. Attendance, 6.

MAY 4. BOWMANS HILL WILDFLOWER PRESERVE, NEW HOPE, PA. The wild flowers and ferns of Pennsylvania have been brought together in this preserve with remarkable success. In spite of the rain much was learned about the plants and the problems of propagating them under these conditions. This was a joint outing with the Academy of Natural Sciences of Philadelphia. Leaders, Edgar T. Wherry and Louis E. Hand. Attendance, about 50 including 9 Torrey members and guests.

MAY 5. BROOKLYN BOTANIC GARDEN. There were many interesting features to be seen at this season. We regret that only one member took time to see them. Our thanks to Mr. Charles Doney just the same.

MAY 5. WATCHUNG RESERVATION, UNION COUNTY, N. J. This was the second annual nature conference held in this area. A rainy morning kept some easily discouraged people from joining the survey walks conducted by the able leaders: Ralph Carver, Mrs. Tollison, David Fables, George Johnson, Guy Nearing, and A. T. Beals. After lunch at the Museum, reports were called for and commented upon by Dr. Richard Weaver. The usual educational displays at Trailside Museum were given much attention by visitors. General leader, James Hawley. Attendance on walks over 50, at the Museum estimated 500.

MAY 5. WEST PARK, N. Y. A visit to "Slabsides," the rustic cabin where John Burroughs spent much time writing, entertaining friends and studying nature lore. The cabin is situated in the midst of a mixed forest of hemlock, birch, beech, and butternut and has not been disturbed since Burroughs' time.

Due to the rain the group was allowed to eat their lunch inside the cabin and observe at first hand the many evidences that Burroughs had a hobby of picking up odd-shaped growths to be utilized in making his cabin comfortable and attractive. We saw bark-covered yellow birch logs used as partitions between the rooms and for the headboards of the beds; a table supported by a sumach tripod; a piece of cypress wood that he had dug up and used as a decorative piece over the doorway; odd shaped roots used for coat hangers; a log, strangled by bittersweet, used as a part of the structure over the fire place and other hand-made articles.

The sun came out in the early afternoon permitting short trips in the forest adjacent to the cabin to see, among other things, the cave where Mr. Burroughs kept his food and where the phoebe, about which he wrote, built its nest year after year. Inspection of the plants along the trail to the spring produced yellow birch (*Betula lutea*), striped maple (*Acer pennsylvanicum*), red-berried elder (*Sambucus racemosa*), sickle-pod (*Arabis canadensis*), early blue violet (*Viola palmata*) and the rarer long-spurred violet (*V. rostrata*), the latter forming large mats along the trail. Other blooming plants were sweet white violet (*Viola blanda*), early saxifrage (*Saxifraga virginiensis*), crinkle-root (*Dentaria diphylla*), lyre-leaved rock cress (*Arabis lyrata*), blue cohosh (*Caulophyllum thalictroides*), and columbine (*Aquilegia canadensis*).

After informal talks by Mr. Julius Burroughs, son of John Burroughs, and Mrs. Kelly, daughter of Julian Burroughs, the group was invited to go to West Park to see "Riverby" and the "Bark-covered Study." John Burroughs named the stone house, which he built when he returned from Washington, D. C. following the Civil War, "Riverby" because it overlooks the Hudson River. Sometime later he built the "Bark covered Study" on the same property but a little nearer the river where he could escape visitors and concentrate on his writing. After this place became too popular he retreated into the forest and built "Slabsides" which is about a mile from his home on the Hudson.

Following the visit to the "Riverby" estate the people who wanted to do some more botanizing and birding were taken on further walks by the leaders: Harold N. Moldenke and Farida A. Wiley. Attendance 46.

May 11–12. Camp Thendara, Palisades Interstate Park, N. Y. Although the weather was not at its best, this trip was profitable and pleasant as always. Dr. Johnson reported a bird list of over 70 species for the two days, comparing favorably with those of recent years. The botanical survey of the Appalachian Trail was pushed from Lake Tiorati traffic circle to the fire-break road east of Black Mountain. Along the dry ridge, the flora was neither extensive nor varied. A moist place at the start increased the list of plants. It was violet season. More impressive to some were the fine views from Black Mountain. Leader and hostess, Mrs. Laura W. Abbott. Botanist, Louis E. Hand. Attendance 42.

May 11–12. Arden, Delaware. All of the interesting things promised in the field schedule were produced ranging from natural plant communities to the beautiful gardens of Mr. Harry duPont. Excursions were conducted on both days and a long list of native, naturalized, introduced, and exotic species was compiled. Leaders, Mr. and Mrs. Morris Berd and Dr. H. N. Moldenke. Attendance: Saturday 10, Sunday 12.

May 12. Woodlands Lake, Westchester County, N. Y. A circuit was made around the lake and south to Nepera Park in spite of the rain. Flowers were plentiful though for the most part not unusual. The rare find was the northern thyme-leaved speedwell (*Veronica humifusa* Dickson) on the east side of Woodlands Lake, usually reported only from northern portions of the state. *V. Chamaedrys* L. was also seen in the woodlands. Thirty-three species of birds were listed. Leader, William Rissanen. Attendance 5.

May 17–19. Branchville Nature Conference at Culvers Lake, N. J. Under the joint management of Mr. Wallace M. Husk and Mr. James Hawley of the Summit Nature Club, we returned to Culvers Lake for a very successful nature conference. The lecture Friday evening was given by Dr. Meredith Johnson, State Geologist, on "New Jersey's Natural Resources." Dr. Johnson took a large group afield on Saturday morning for a study of various rock exposures west of Kittatiny Ridge: Wisconsin glacial drift, Onondaga limestone, Esopus grit, Oriskany limestone, High Falls formation, and Martinsburg formation. David Fables led bird walks mornings, forenoons, and afternoons. He gave an illustrated talk featuring bird calls on Saturday evening. "Bill" Hassler likewise was afield at all hours. He filled innumerable vivaria with reptiles and amphibia of the area, displaying nearly all of the forms to be expected hereabouts. Mr. Hassler gave an evening lecture illustrated with a beautiful movie in kodachrome which he had made with the cooperation of very able and obliging actors. Mildred Rulison led groups for flowering plants in different sorts of places while Mr. Herbert Dole scored the ferns. There was an interesting session on insects after lunch on Saturday and another after breakfast on Sunday. Louis E. Hand and John A. Small led three walks on the Appalachian Trail. These groups attempted to list all plants to be seen by hikers along these portions of the Trail, a list of over 150 species being compiled. The Appalachian Trail lecture was given Saturday evening with kodachrome stills of interesting spots between Mt. Katahdin in Maine and Mt. Oglethorpe 2050 miles away in Georgia, supplied through the courtesy of the Appalachian Trail Conference, 1916 Sunderland Place, N. W., Washington 6, D. C.

Eighty-three were registered for the whole conference while about 20 others participated to a lesser extent. An incomplete list of clubs represented includes: Mountain Club of Maryland, Palmerton (Pa.) Bird Club, Philadelphia Botanical Club, Watchung Nature Club, Garden Clubs of N. J., Westfield Bird Club, Union County (N. J.) Park Commission, Newark Museum Nature Club, Chatham Nature Club, Summit Nature Club, Audubon Society, and Linnean Society, but we should have especially liked to hear the report made by the representative of the Gourmet Society.

Our thanks to all the leaders, to Mr. and Mrs. Warburg and staff of Haltere Hotel, including our friends Mr. and Mrs. Haltere, and to Messrs. Hawley and Husk who apparently never slept.

MAY 18. SILVER LAKE, WESTCHESTER COUNTY, N. Y. This rich woodland area has been reported other years. Species attracting most attention were dwarf ginseng, blue cohosh, white baneberry, wild ginger, early blue violet, yellow violet (*V. hastata*), bulbous cress, and the many other woodland species. Sixty birds were seen or heard. Leader, Farida A. Wiley. Attendance 8.

MAY 25–26. PINE BARRENS CANOE VOYAGE, N. J. The group assembled at Forked River and took a Saturday afternoon walk around the three lakes on the Upper Fork, renewing acquaintance with the usual pine barrens plants. The beauty of the pitcher plant in full anthesis was most outstanding. Pine barrens heather was in flower. The earliest bladderworts and pipeworts brightened the bogs. Dinner at Greyhound Hotel can be appreciated only by those participating.

Driving to Lake Oswego Sunday morning we traversed the tall pine oak forest, the plains, and skirted a cranberry bog. An obliging (to the photographer) pine snake and less obliging fence lizards were seen. Canoes were put in the Oswego just below the dam in Penn Forest. The cruise of nearly three hours to upper Martha bog and an hour and a half on to Harrissa after lunch was called pleasant by all. Each canoe crew had its own opportunity to recognize the plants as we glided along on the current, sometimes pausing to compare notes and other times pausing with problems of navigation. No composite list was made but this was the season for dangleberry and fetterbush, with now and then magnolia in flower. Several bogs, passed up in the uncertainty about time, invite us to a more leisurely return. Curly grass fern and Conrad's crowberry were produced for those desiring to see these plants. Leaders, Louis E. Hand and John A. Small. Attendance 16.

MAY 26. SPRINGDALE, N. J. for limestone inhabiting plants. "We didn't see anything very remarkable but the flora in that district is always interesting." Leader, G. G. Nearing. Attendance 9.

MAY 26. WATCHUNG RESERVATION, UNION COUNTY, N. J. The second annual open house for hikers found some dozen or more clubs represented. Hikes were offered in the Reservation for various objectives including the flora of the various habitats represented. Leaders, Mildred Rulison and James Hawley. There was a large attendance but no count of hikers or Torrey members is at hand.

MAY 30. MORRISTOWN, N. J. Due to failure in connecting, this trip went off in two sections. The more interesting one was to the Great Swamp where the matricary grape fern and a rare lichen (*Pleuridium subulatum*) rewarded the group in addition to an abundance of *Viola lanceolata* and *V. prunifolia*. The estranged group took in all the features of the Morristown National Historical Park, including the nature trail and the old-fashioned garden at Tempe Wick's house. Leader, Lois Wenman. Attendance 14.

JUNE 1. SOUTHERN PORTION OF STATEN ISLAND. Although it proved too early for seeing lotus in flower a number of other things of interest were found. Mr. Napier substituted for Mr. L. A. Ellison as leader. Attendance 8

JUNE 1. ATLANTIC BEACH, LONG ISLAND. This outing as guests of the Department of Natural History of Brooklyn Institute was devoted primarily to marine invertebrates of which some 31 species were seen. Several species of marine algae were recorded. "This place is a new sandbar with rapidly shifting populations, this year for the first time the dunes are overrun with ragwort (*Senecio aureus*)." Leader, Grace Peterson. Attendance 40.

JUNE 2. It rained too much for trail clearing so the announced leader failed to go but you cannot rain out some botanists. *Cladonia floridana* was found on the Appalachian

Trail where it follows Flatbrookville road. This is the only known collection of the species on the Trail except one at High Point. Leader, G. G. Nearing. Attendance 3.

JUNE 9. WASHINGTON VALLEY AND WATCHUNG MOUNTAINS NEAR PLAINFIELD, N. J. This walk through Wetumpka Notch included geology, ecological aspects, and various floral aspects along the way. A species list for this part of N. J. has been published by the leader as, "Observed Flora of the Vicinity of Watchung, N. J." Leader, Harold N. Moldenke. Attendance 32.

JUNE 15–16. LAKE SHEHAWKIN, WAYNE COUNTY, PA. "Everybody was enthusiastic and enjoyed the pleasure of new fields and woods." Leader, W. L. Dix. Attendance 12.

JUNE 15. THE CHILDREN'S GARDEN, BROOKLYN BOTANIC GARDEN. "These Torrey members were a pleasure to have for they were pretty enthusiastic about what they saw—the out-of-door laboratory with about 200 youngsters under foot but all having a good time." Leaders, Frances Miner and Barbara Shalucha. Attendance 5.

JUNE 16. KISSENA PARK, QUEENS, N. Y. "We followed the list of the Brooklyn Botanic Garden Leaflet of Dec. 1936 entitled, 'The Rare Trees and Shrubs of Kissena Park, Flushing, L. I., N. Y.' and found most of the trees mentioned. Some seem to have disappeared and the paths have been changed somewhat by the W.P.A. .The swamp adjacent is being filled in and we had hopes of finding specimens there but not any more. After Kissena Park, we went to see that giant weeping beech about a mile or so away and found it doing well." Leader, William Rissanen. Attendance 12.

JUNE 23. HASKELL, N. J. There were thirteen on this trip and it appears that four of them were kept busy finding trails, identifying specimens, answering questions generally, and pointing out things of interest. No wonder the trip was called successful. Our thanks also to the North Jersey District Water Supply Commission for their permission to cross normally restricted property. Leaders, Albert and Vivian Schatz.

JUNE 23. HOPEWELL VILLAGE AND FALLS OF FRENCH CREEK, CHESTER CO., PA. Joint trip as guests of the Academy of Sciences of Philadelphia. Several stops were made for interesting studies of bird life, geology and minerals. Three botanical forays were made. *Conopholis americana*, *Liparis liliifolia*, *Pyrola americana*, *Scutellaria pilosa*, *Dryopteris Bootii*, and *Dryopteris Slossonae* (= *D. marginalis* × *D. cristata*) were among the features reported. Two fern students listed 21 species in the course of the trip. Of something over 100 participating, 4 were recognized from the Torrey Club. Leader, for T.B.C., Louis Hand.

JUNE 30. VAN CORTLANDT PARK AND WESTCHESTER CO., for general nature exploration. Plants, butterflies, and even a box turtle came up for consideration. Leader, Eleanor Friend, attendance 11.

JULY 6. GREAT SWAMP, MORRIS COUNTY, N. J. Various areas were traversed the most exciting plant discovered was *Ophioglossum vulgatum*. Leader, G. G. Nearing. Attendance 9.

JULY 7. BORDENTOWN, N. J. Several remarkable specimens of woody plants were observed at the Bonapart Estate and at the farm of the late Charles Conrad Abbott. Leader, Mr. Charles R. Moorhead. Attendance 10.

JULY 13. WEST ORANGE, N. J., to visit fern garden. "The ferns were in fine condition except for some of the taller ones that had been broken during a recent thunder storm. One each of every species and variety had been tagged with markers for the benefit of those unfamiliar with fern names; both botanical and common names being given.

There were 85 of the markers. . . . Several new varieties have been added to the collection, including a fine specimen of *Polypodium virginianum* f. *cambricoides*, and *Dryopteris intermedia* var. *concordiana*. Leader, W. H. Dole. Attendance, 20.

JULY 14. MILBURN, N. J. A good stand of *Allium tricoccum* was found "which though common enough, is not always found in flower . . . I believe we found a good specimen of *Hypoxylon punctatum* on an old Shagbark Hickory." Leader, William Rissanen. Attendance, 20.

JULY 27. WARD'S POINT, STATEN ISLAND. "Besides the more usual things for the locality, we found *Allionia nyctaginea* which seems to persist from year to year. It was interesting to find a thriving colony of *Tripsacum dactyloides*. This grass is found at several places on Staten Island but I have never seen it near the point. Perhaps this is a new record for the locality." Leader, Charles Ericson. Attendance, 14.

JULY 28. PREAKNESS HILLS for lichens and fungi. "Nothing unusual except that *Stereocaulon pileatum*, a supposedly rare species which we have previously found very plentiful on Beech Mountain nearby, was found also on High Mountain." Leader, G. G. Nearing. Attendance, 19.

AUGUST 11. SEELEY'S NOTCH, N. J. A study of the general flora and ecology of the region. Leader, H. N. Moldenke. Attendance, 33.

AUGUST 18. UPPER GREENWOOD LAKE, N. J. Additional work on the botanical survey of the Appalachian Trail. Over 320 species were recorded. Worked east from Brady Road but did not reach Surprise Lake. Fungi were plentiful and varied. Leader, G. G. Nearing. Attendance, 8.

NEWS NOTES

Members of the Club interested in field work will be glad to learn that Dr. William M. Harlow, of the New York State College of Forestry at Syracuse, has published a "Fruit Key to Northeastern Trees." This is a small booklet of 50 pages and 129 small photographs illustrating most of the species treated, besides other illustrations in the Introduction. It is a companion volume to the author's "Twig Key to the Deciduous Woody Plants of Eastern North America."

The American Optical Company has recently announced a new development called the phase microscope which facilitates the observation of transparent material. The equipment necessary to transform an ordinary light microscope into a phase microscope consists of a diaphragm, which produces a hollow cone of light, and a new diffraction plate placed within the objective lens system. The diffraction plate changes the light in such a way that details in a transparent specimen can be observed. Many materials are so transparent that nothing can be seen with a regular microscope, yet their internal structures usually do have differences in optical path which alter the phase of light passing through them. The invisible phase differences of the light are converted into illumination differences to which the eye is sensitive. Any regions within the specmen of different optical path can be made bright on a dark background or dark on a light background, depending on the kind of diffraction plate used. The phase microscope will make possible the study of transparent living organisms without the use of stains. It can also be used to study emulsions, glass and plastic transparent surfaces, minerals, crystals, synthetic fibers, and other materials.

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